Part I
Getting Started

Chapter 1
Building Partnerships

Contents

Building Partnerships

Build a partnership through an active involvement program designed to build trust and credibility between a company that generates and manages waste, the community within which the company lives and works, and the state agency that regulates the industry.

Residents located near waste management units want to understand the management activities taking place in their neighborhoods. They want to know that waste is being managed safely, without danger to public health or the environment. Create opportunities for dialogue between industries, states, and concerned citizens before decisions are made. Partnership efforts also need to be ongoing in order to be successful.

I. Benefits of Building Partnerships

Building partnerships in the decision-making process provides a number of benefits:

- Enhanced understanding of waste management activities at an industrial facility;
- Enhanced understanding of industry, state, and community concerns;
- Greater support of industry and state policies;
- Reduced delays and costs associated with opposition and litigation; and
- A positive image and relationship.

II. Principles of Building Partnerships

Regardless of the size or type of an industry waste unit, industries, states, and local communities can all follow similar principles of building partnerships. These principles are based on various state public involvement guidance documents, various EPA publications, and state requirements for waste facilities. These principles embody sound business practices and common sense, and may go beyond state requirements that call for public participation during the issuance of a permit. This guidance document recommends principles that can be adopted throughout the operating life of facilities, not just during the permitting process. Following these principles

This chapter will help address the following questions:

• What are the benefits of building partnerships?

• What building partnership methods have been successful?

• What is involved in preparing a meeting?

will help all involved consider the full range of activities possible to give partners an active voice in the decision-making process, and in so doing, will result in a positive working relationship.

A. Develop a Partnership Involvement Plan

The key to effective involvement, like any activity, is good planning. Developing a plan for how and when to involve all parties in the decision-making process will help to make involvement activities run smoothly and achieve the best results. Developing an involvement plan also helps identify concerns and determine which involvement activities best address those concerns.

The first step in developing an involvement plan is to work with the state agency to understand what involvement requirements exist. (State contacts are provided in Appendix I.) Existing state requirements dealing with involvement plans must be followed.

After this step, it will be important to assess how much interest facility activities will generate in the community. Several criteria influence the amount of public interest, including implications for public health and welfare, current relationships between the facility and community members, and the community's political and economic climate. Even if facilities have not generated much public interest in the past, involving the public is a good idea. Interest in a facility can increase suddenly when changes to existing activities are proposed or when residents' attitudes and a community's political or economic climate change over time.

To gauge public interest in a facility and to identify the community's major concerns, industries can conduct interviews with community members. They can first talk with representatives from major community groups, such as civic groups, religious organizations, and business associations. If interest in the facility seems high, industries can consider conducting a more comprehensive set of community interviews. Other individuals to interview may include the facility's immediate neighbors, representatives from other agencies and environmental organizations, and any individuals in the community who have expressed interest in the facility.

Using the information gathered during the interviews, industries can develop a list of the major community concerns regarding the facility. They can then begin to engage in involvement activities necessary to address those concerns. These activities form the basis of a partnership involvement plan.

B. Inform the State and Public About New Facilities or Significant Changes in Facility Operating Plans

A facility's decision to change its operations provides a valuable opportunity for involvement. Notifying the state and public of new facilities and proposed changes gives them the opportunity to identify applicable state requirements and comment on matters that apply to them.

What are examples of effective methods for notifying the public?

Table 1 presents examples of effective methods for public notification and associated advantages and disadvantages. The method used at a particular site, and within a particular community, will depend on the type of information or issues that need to be communicated and addressed. Public notices usually provide the name and address of the facility owner and operator and a brief description of the change being considered. After a public notice is issued, industries can develop informative fact sheets to explain proposed changes in more detail. Fact sheets and public notices can include the name and telephone number of a contact person who is available within the industry to answer questions.

Table 1
Effective Methods for Public Notification

Methods	Features	Advantages	Disadvantages
Briefings	Personal visit or phone call to key officials or group leaders to announce a decision, provide background information, or answer questions.	Provides background information. Determines reactions before an issue "goes public." Alerts key people to issues that may affect them.	Requires time.
Mailing of key technical reports or environmental documents	Mailing technical studies or environmental reports to other agencies, leaders of organized groups, or other interested parties.	Provides full and detailed information to people who are most interested. Often increases the credibility of studies because they are fully visible.	Costs money to print and mail. Some people might not read the reports.
News conferences	Brief presentation to reporters, followed by a question-and-answer period, often accompanied by handouts of presenter's comments.	Stimulates media interest in a story. Direct quotes often appear in television and radio. Might draw attention to an announcement or generate interest in public meetings.	Reporters will only come if the announcement or presentation is newsworthy. Cannot control how the story is presented, although some direct quotes are likely.
Newsletters	Brief description of what is going on, usually issued at key intervals for all people who have shown interest.	Provides more information than can be presented through the media to those who are most interested. Often used to provide information prior to public meetings or key decision points. Helps to maintain visibility during extended technical studies.	Requires staff time. Costs money to prepare, print and mail. Stories must be objective and credible, or people will react to the newsletters as if they were propaganda.
Newspaper inserts	Much like a newsletter, but distributed as an insert in a newspaper.	Reaches the entire community with important information. Is one of the few mechanisms for reaching everyone in the community through which you can tell the story your way.	Requires staff time to prepare the insert, and distribution costs money. Must be prepared to newspaper's layout specification.
Paid advertisements	Advertising space purchased in newspapers or on the radio or television.	Effective for announcing meetings or key decisions or as background material for future media stories.	Advertising space can be costly. Radio and television may entail expensive production costs to prepare the ad.
News releases	A short announcement or news story issued to the media to get interest in media coverage of the story.	Might stimulate interest from the media. Useful for announcing meetings-or omajor decisions or as background material for future media stories.	Might be ignored or not read. Cannot control how the information is used.

Table 1
Effective Methods for Public Notification (cont.)

Methods	Features	Advantages	Disadvantages
Presentations to civic and technical groups	Deliver presentations, enhanced with slides or overheads, to key community groups.	Stimulates communication with key community groups. Can also provide in-depth responses.	Few disadvantages except some groups can be hostile.
Press kits	A packet of information distributed to reporters.	Stimulates media interest in the story. Provides background information that reporters can use for future stories.	Few disadvantages except cannot control how the infor- is used and might not be read.
Advisory groups and task forces	A group of representatives of key interested parties is established. May be a policy, technical, or citizen advisory group.	Promotes communication between key constituents. Anticipates public reaction to publications or decisions. Provides a forum for reaching consensus.	Potential for controversy exists if "advisory" recommendations are not followed. Requires substantial commitment of staff time to provide support to committees.
Focus groups	Small discussion groups established to give "typical" reactions of the public. Conducted by a professional facilitator. Several sessions may be conducted with different groups.	Provides in-depth reaction to ideas or decisions. Good for predicting emotional reactions.	Gets reactions, but no knowledge of how many people share those reactions. Might be perceived as an effort to manipulate the public.
Telephone line	Widely advertised phone number that handles questions or provides centralized source of information.	Gives people a sense that they know whom to call. Provides a one-step service of information. Can handle two-way communication.	Is only as effective as the person answering the telephone. Can be expensive.
Meetings	Less formal meetings for people to present positions, ask questions, and so forth.	Highly legitimate form for the public to be heard on issues. Can be structured to permit small group interaction—anyone can speak.	Unless a small group discussion format is used, it permits only limited dialogue. Can get exaggerated positions or grandstanding. Requires staff time to prepare for meetings.

U.S. EPA 1990. *Sites for Our Solid Waste: A Guidebook for Effective Public Involvement.*

What is involved in preparing a meeting with industry, community, and state representatives?

Meetings can be an effective means of giving and receiving comments and addressing concerns. To publicize a meeting, the date, time, and location of the meeting should be placed in a local newspaper and/or advertised on the radio. To help ensure a successful dialogue, meetings should be at times convenient for members of the community, such as early in the evenings during the week, or on weekends. An interpreter may need to be obtained (hire or seek a volunteer) if the local community includes residents whose primary language is not English.

Prior to a meeting, an industry should develop a waste management plan for the facility or come to the meeting prepared to describe how the industrial waste from the facility will be managed. A waste management plan provides a starting point for public comment and input. Keep data presentations simple and provide information relevant

to the audience. Public speakers should be able to respond to general questions, as well as technical questions. Also, industry should review and be familiar with the concerns of groups or citizens who have previously expressed an interest in the facility. In addition, it is important to anticipate questions and plan how best to respond to these questions at a meeting.

State representatives should also be prepared to answer questions that are anticipated at the meeting. State representatives should be prepared to answer questions on specific regulatory or compliance issues, as well as to address how the industry has been working in cooperation with the state agency.

Questions often asked at a meeting include:

- What are the risks to me associated with the operations?
- Who should I contact at the facility if I have a question or concern?
- How will having the facility nearby benefit the area?
- Will there be any noticeable day-to-day effects on the community?
- Which processes generate industrial waste, and what types of waste are generated?
- How will the waste streams be treated or managed?
- What are the construction plans for any proposed containment facilities?
- What are the intended methods for monitoring and detecting emissions or potential releases?
- What are the plans to address accidental releases of chemicals or wastes at the site?
- What are the plans for financial assurance, closure, and post-closure care?
- What are the applicable state regulations?
- How long will it take to issue the permit?
- How will the permit be issued?
- Who should I contact at the state agency if I have questions or concerns about the facility?

At the meeting, industry should invite public and state comments on the proposed change, and tell community members where, and to whom they should send written comments. Industry can choose to respond to comments in several ways. For example, telephone calls, additional fact sheets, or additional meetings can all be used to address comments. Responding promptly to residents' comments and concerns demonstrates an honest attempt to address them.

C. Make Knowledgeable and Responsible People Available for Sharing Information

Having an industry contact(s) available to answer the public's questions and provide information helps assure citizens that the industry is actively listening to their concerns. Having a state contact available to address the public's concerns about the facility can also make sure that concerns are being heard and addressed.

In addition to identifying a contact person, industry and states should consider setting up a telephone line, staffed by employees, for citizens to call and obtain information promptly about the facility. Opportunities for face-to-face interaction between community members and facility representatives include onsite information offices, open houses, workshops, or briefings. Information offices function similarly to information repositories, except that an employee is present to answer

questions. Open houses are informal meetings on-site where residents can talk to company officials one-to-one. Similarly, workshops and briefings enable community members, state officials, and industry representatives to interact, ask questions, and learn about the activities at the facility. Web sites may also serve as a useful tool for industry, state, and community representatives to share information and ask questions.

D. Provide Information About Facility Operations

Providing information about site operations is an invaluable way to help the public understand waste management activities at a site. Facility tours, maintaining a publicly accessible information repository at the site, developing exhibits to explain operations, and distributing information through the publications of established organizations are examples that can serve to inform a community. Appendix II describes some of the public involvement activities that are being conducted by various companies around the country.

Conduct facility tours. Scheduled facility tours allow the community and state to visit the facility and ask questions about how it operates. By seeing a facility first-hand, residents learn how waste is managed and can become more confident that it is being managed safely. Individual citizens, local officials, interest groups, students, and the media might want to take advantage of facility tours. In planning tours, determine the maximum number of people that can be taken through the facility safely, and think of ways to involve tour participants in what they are seeing, such as providing hands-on demonstrations. It is also a good idea to have company individuals available to answer technical questions in an easy-to-understand manner.

Maintain a publicly accessible information repository. An information repository is simply a collection of documents describing the facility and its activities. It can include background information on the facility, the involvement plan (if developed), permits to manage waste on-site, fact sheets, and copies of relevant guidance and regulations. The repository should be in a convenient, publicly accessible place. Repositories are often maintained on-site in a public "reading room" or off-site at a public library, town hall, or public health office. Industry should publicize the existence, location, and hours of the repository and update the information regularly.

Develop exhibits that explain facility operations. Exhibits are visual displays, such as maps, charts, diagrams, or photographs, accompanied by brief text. They provide technical information in an easily understandable way and give an opportunity to illustrate issues of concern creatively and informatively. When developing exhibits, identify the target audience, clarify which issue or aspect of the facility's operations will be the exhibit's focus, and determine where the exhibit will be displayed. Public libraries, convention halls, community events, and shopping centers are all good, highly visible locations for an exhibit.

Use publications and mailing lists of established local organizations. Existing groups and publications often provide access to established communication networks. Take advantage of these networks to minimize the time and expense required to develop mailing lists and organize meetings. Civic or environmental groups, rotary clubs, religious organizations, and local trade associations might have regular meetings, newsletters, newspapers, or magazines, as well as mailing lists, that could be useful in reaching interested members of the community.

III. Understanding Risk Assessment

Environmental risk communication skills are critical to successful partnerships between industry, the public, and other stakeholders. As more environmental management decisions are made on the basis of risk, it is increasingly important for all interested parties to understand the science behind risk assessment. Encouraging public participation in environmental decision-making means ensuring that all interested parties understand the basic principles of risk analysis and can converse equally on the development of assumptions that underlie the analysis.

A. Introduction to Risk Assessment

This guidance document provides simple-to-use risk assessment tools that can assist in determining the appropriate waste management practices for surface impoundments, landfills, waste piles, and land application units. The guidance tools are based on predicting potential human health impacts from a waste management unit by modeling two possible exposure pathways: releases through volatile air emissions and contaminant migration into ground water. Although applying the guidance tools is simple, it is still essential to understand the basic concepts of risk analysis to be able to interpret the results and understand the nature of any uncertainties associated with the analysis. This section provides a general overview of the scientific principles underlying the methods for quantifying cancer and noncancer risk assessment. Ultimately, understanding the scientific principles will lead to more effective use of the guidance tools.

B. Types of Risk

Risk is a concept used to describe situations or circumstances that pose a hazard to people or things they value. People encounter a myriad of risks during common everyday activities, such as driving a car, investing money, and undergoing certain medical procedures. By definition, risk is comprised of two components: the probability that an adverse event will occur and the magnitude of the consequences of that adverse event. As such, in capturing these two components, risk is typically stated in terms of the probability (e.g., one chance in one million) of a specific harmful "endpoint" (i.e., accident, fatality, cancer).

In the context of environmental management, and in the context of this section in the guidance document, risk is defined as the probability or likelihood that public health may be impacted from exposure to chemicals contained in waste management units. The risk endpoints resulting from the exposure are typically grouped into two major consequence categories: cancer risk and noncancer risk.

As implied, the cancer risk category captures risks associated with exposure to chemicals that may initiate cancer. To determine a cancer risk, one must calculate the probability of an individual developing any type of cancer during his or her lifetime from exposure to carcinogenic hazards. Cancer risk is generally expressed in scientific notation; in this notation, the chance of 1 person in 1,000,000 of developing cancer would be expressed as 1 x 10^{-6} or $1E^{-6}$. The noncancer risk category is essentially a catch-all category for the remaining health effects resulting from chemical exposure. Noncancer risk encompasses a diverse set of effects or endpoints, such as weight loss, enzyme changes, reproductive and developmental abnormalities, and respiratory reactions. Noncancer risk is generally assessed by comparing the exposure or average intake of a chemical with a corresponding reference (a health benchmark), thereby creating a ratio. The ratio so generated is referred to as the hazard quotient (HQ). An HQ that is greater than 1 indicates that the exposure level is above the protective level of the health benchmark, whereas, an HQ less than 1 indicates that the exposure is below the protective level established by the health benchmark.

It is important to understand that exposure to a chemical does not necessarily result in an adverse health effect. A chemical's ability to initiate a harmful health effect depends on the toxicity of the chemical as well as the route (i.e., ingestion, inhalation) and dose (the amount that a human intakes) of the exposure. Health benchmark values are used to quantify a chemical's possible toxicity and ability to induce a health effect, and are derived from toxicity data. They represent a "dose-response" estimate that relates the likelihood and severity of adverse health effects to exposure and dose. The health benchmark is used in combination with an individual's exposure level to determine if there is a risk. Because individual chemicals generate different health effects at different doses, benchmarks are chemical specific; additionally, since health effects are related to the route of exposure and the timing of the exposure, health benchmarks are specific to the route (ingestion or inhalation) and the duration (acute, subchronic, or chronic) of the exposure. The definitions of acute, subchronic and chronic exposures vary, but acute typically implies an exposure of less than one day, subchronic generally indicates an exposure of a few weeks to a few months, and chronic exposure can span periods of several months to several years.

The health benchmark for carcinogens is called the cancer slope factor. A cancer slope factor (CSF) is defined as the upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime and is expressed in units of $(mg/kg\text{-}d)^{-1}$. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular concentration of a carcinogen.

A reference dose (RfD) for oral exposure and reference concentration (RfC) for inhalation exposure are used to evaluate noncancer effects. The RfD and RfC are estimates of daily exposure levels to individuals (including sensitive populations) that are likely to be without an appreciable risk of deleterious effects during a lifetime and are expressed in units of mg/kg-d (RfD) or mg/m^3 (RfC).

Most health benchmarks reflect some degree of uncertainty because of the lack of precise toxicological information on the people who might be most sensitive (e.g., infants, elderly, and nutritionally or immunologically

Example of Health Benchmarks Acrylonitrile

Chronic:
- inhalation CFS: $0.24(mg/kg/d)^{-1}$
- oral CFS: $0.54\ (mg/kg/d)^{-1}$
- RIC: 0.002 mg/m^3
- RfD:0.001 mg/kg/d

Subchronic:
- RfC: 0.02 mg/m^3

Acute:
- ATSDR MRL: 0.22 mg/m^3

compromised) to the effects of hazardous substances. There is additional uncertainty because most benchmarks must be based on studies performed on animals, as relevant human studies are lacking.

There are several sources for obtaining health benchmarks, some of which are summarized in the text box. Note that from time-to-time benchmark values may be revised to reflect new toxicology data on a chemical. In addition, because many states may have developed their own toxicology benchmarks, both the ground-water and air tools in this guidance enable a user to input an alternative benchmark to those that are provided.

C. Assessing Risk

Typically risk is estimated using the organized process of evaluating scientific data known as risk assessment. Risk assessment ultimately serves as guidance for making management decisions by providing one of the inputs to the decision making process. Risk assessment furnishes beneficial information for a variety of situations, such as determining the appropriate pollution control systems for an industrial site, predicting the appropriateness of different waste management options or alternative waste management unit configurations, or identifying exposures that may require additional attention.

Sources for Health Benchmarks

Integrated Risk Information System (IRIS) The Integrated Risk Information System (IRIS) is the Agency's official repository of Agency-wide consensus chronic human health risk information. IRIS is an EPA data base containing Agency consensus scientific positions on potential adverse human health effects that may result from chronic (or lifetime) exposure to environmental contaminants. IRIS information includes the reference dose for noncancer health effects resulting from oral exposure, the reference concentration for noncancer health effects resulting from inhalation exposure, and the carcinogen assessment for both oral and inhalation exposure.

Health Effects Assessment Summary Tables (HEAST)
HEAST is a comprehensive listing compiled by the EPA consisting of risk assessment information relative to oral and inhalation routes for chemicals. HEAST benchmarks are considered secondary to those contained in IRIS. Although the entries in HEAST have undergone review and have the concurrence of individual agency program offices, they have either not been reviewed as extensively as those in IRIS or they do not have as complete a data set as is required for a chemical to be listed in IRIS.

Agency for Toxic Substances and Disease Registry (ATSDR)
The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), requires that the Agency for Toxic Substances and Disease Registry (ATSDR) develop jointly with the EPA, in order of priority, a list of hazardous substances most commonly found at facilities on the CERCLA National Priorities List; prepare toxicological profiles for each substance included on the priority list of hazardous substances; ascertain significant human exposure levels (SHELs) for hazardous substances in the environment, and the associated acute, subchronic, and chronic health effects; and assure the initiation of a research program to fill identified data needs associated with the substances. The ATSDR Minimal Risk Levels (MRLs) were developed as an initial response to the mandate. MRLs are based on noncancer health effects only and are not based on a consideration of cancer effects. MRLs are derived for acute (1-14 days), intermediate (15-364 days), and chronic (365 days and longer) exposure durations, for the oral and inhalation routes of exposure.

The risk-evaluation process involves data collection activities, such as identifying and characterizing the source of the environmental pollutant, determining the transport of the pollutant once it is released into the environment, determining the pathways of human exposure, and identifying the extent of exposure for individuals or populations at risk. Performing a risk assessment is complex and requires knowledge in a number of scientific disciplines. Experts in several areas, such as toxicology, geochemistry, environmental engineering, and meteorology, may be involved in performing a risk assessment. For the purpose of this section, and for brevity, the basic components important to consider when assessing risk are summarized in three main categories listed below. A more extensive discussion of these components can be found in the references listed at the end of this section.

The three main categories are:

1. **Hazard Identification:** identifying and characterizing the source of the potential risk (e.g., chemicals managed in a waste management unit).
2. **Exposure Assessment:** determining the accessibility or avenues from the source to an individual (i.e., exposure pathways and exposure routes).
3. **Risk Characterization:** integrating the results of the exposure assessment with information on who is potentially at risk (e.g., location of the person, body weights, etc.) and toxicity information on the chemical.

1. Hazard Identification

For the purpose of this guidance document, the source of the potential risk has already been identified: waste management units. However, there must be a release of chemicals from a waste management unit for there to be exposure and risk. Chemicals may be released from waste management units by a variety of processes, including volatilization (where chemicals in vapor phase are released to the air), leaching to ground water (where chemicals travel through the ground to a ground-water aquifer), particulate emission (where chemicals attached to particulate matter are released in the air when the particulate matter becomes airborne), and run-off and erosion (where chemicals in soil water or attached to soil particles move to the surrounding area).

To consider these releases in a risk assessment, information characterizing the waste management unit is needed. Critical parameters include the size of the unit and its location. For example, larger units tend to produce larger releases. Units located close to the water table might produce greater releases to ground water than units located further from the water table. Units located in a hot, dry, windy climate may produce greater volatile releases than units in a cool, wet, non-windy climate.

2. Exposure Assessment: Pathways, Routes, and Estimation

Individuals and populations may come into contact with environmental pollutants by a variety of exposure mechanisms and processes. The mere presence of a hazard, such as toxic chemicals in a waste management unit, does not denote the existence of a risk. Exposure is the bridge between what is considered a hazard and what actually presents a risk. Assessing exposure involves determining the pathways and extent of human contact with toxic chemicals. The magnitude, frequency, duration, and route of exposure to a substance must be considered when collecting all of the data necessary to construct a complete exposure assessment.

The steps for performing an exposure assessment include identifying the potentially exposed population (receptors); pathways of exposure; environmental media that transport the contaminant; contaminant concentration at a receptor point; and receptor's exposure time, frequency, and duration. The output of the exposure assessment is a numerical estimate of exposure and intake of a chemical by an individual. The intake information is then used in concert with chemical-specific health benchmarks to quantify risks to human health.

Before gathering these data, it is important to understand what information is necessary for conducting an adequate exposure assessment and what type of work may be required. Exposures are commonly determined by using mathematical models of chemical fate and transport to determine chemical movement in the environment in conjunction with models of human activity patterns. The information required for performing the exposure assessment includes site-specific data such as soil type, meteorological conditions, ground-water pH, and location of the nearest receptor. Information must be gathered for the two components of exposure assessment: exposure pathways/routes and exposure quantification/estimation.

a. Exposure Pathways/Routes

An exposure pathway is the course the chemical takes from its source to the individual or population it reaches. Chemicals cycle in the environment by crossing through the different types of media which are considered exposure pathways: air, soil, ground water, surface water, and biota (Figure 1). As a result of this movement, a chemical can be present in various environmental media, and human exposure often results from multiple sources. The relative importance of an exposure pathway depends on the concentration of a chemical in the relevant medium and the rate of intake by the exposed individual. In a comprehensive risk assessment, the risk assessor identifies all possible site-specific pathways through which a chemical could move and reach a receptor. This guidance document provides tools to model the transport and movement of chemicals through two environmental pathways: air and ground water.

The transport of a chemical in the environment is facilitated by natural forces: wind and water are the primary physical processes for distributing contaminants. For example, atmospheric transport is frequently caused by ambient wind. The direction and speed of the wind determine where a chemical can be found. Similarly, chemicals found in surface

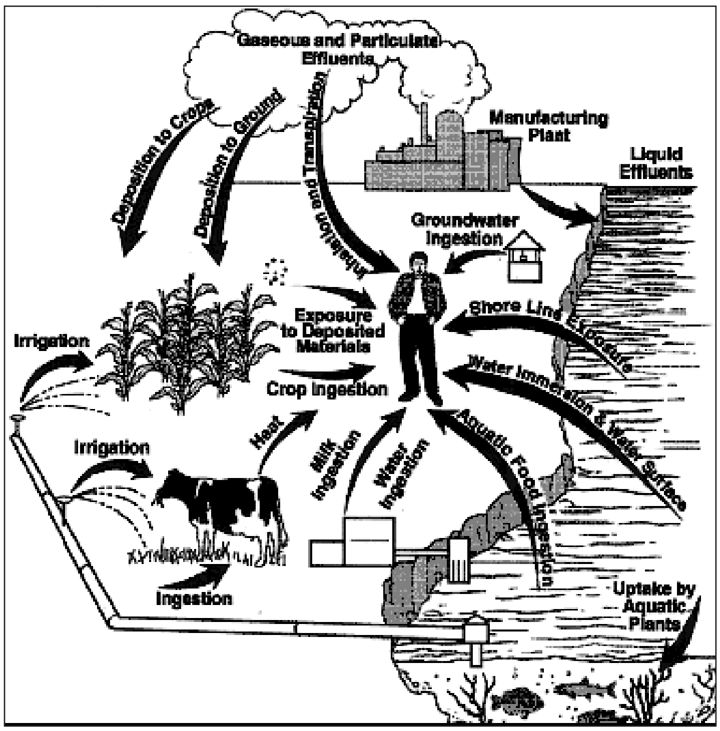


Figure 1. Multiple Exposure Pathways/Routes *(National Research Council, "Frontiers in Assesssing Human Exposure," 1991)*

water and ground water are carried by water currents or sediments suspended in the water. The chemistry of the contaminants and of the surrounding environment, often referred to as the "system," also plays a significant role in determining the ultimate distribution of pollutants in the various types of media. Physical-chemical processes, including dissolution/precipitation, volatilization, and photolytic and hydrolytic degradation, as well as sorption and complexation, can influence the distribution of chemicals among the different environmental media and the transformation from one chemical form to another.[1] An important component of creating a conceptual model for performing a risk assessment is the identification of the relevant processes that occur in a system. These complex processes depend on the conditions at the site and specific chemical properties.

Whereas the exposure pathway dictates the means by which a contaminant can reach an individual, the exposure route is the way in which that chemical enters the body. To generate a health effect, the chemical must come in contact with the body. In environmental risk assessment, three exposure routes are generally considered: ingestion, inhalation, and dermal absorption. As stated earlier, the toxicity of a chemical is specific to the dose received and its means of entry into the body. For example, a chemical that is inhaled may prove to be toxic and

Key Chemical Processes

Sorption: the ability of a chemical to partition between the liquid and solid phase by determining its affinity for adhering to other solids in the system such as soils and sediment. The amount of chemical that "sorbs" to solids and does not move through the environment is dependent upon the characteristics of the chemical, the characteristics of the surrounding soils and sediments, and the quantity of the chemical. A sorption coefficient is the measure of a chemical's ability to sorb. If too much of the chemical is present, the available binding sites on soils and sediments will be filled and sorption will not continue.

Dissolution/precipitation: the extent to which a substance will be found in a soluble form versus a solid form. In dissolution a chemical is taken into solution; precipitation is the formation of an insoluble solid. These processes are a function of the nature of the chemical and its surrounding environment and are dependent on properties such as temperature and pH. A chemical's solubility is characterized by a solubility product. Chemicals that tend to volatilize rapidly are not highly soluble.

Degradation: the propensity and extent a chemical will break down into other substances in the environment. Some degradation processes include biodegradation, hydrolysis, and photolysis. Not all degradation products have the same risk as the "parent" compound. Some chemicals can break into "daughter" products that are more harmful than the parent substance. In performing a risk assessment it is important to consider what the daughter products of degradation may be.

Bioaccumulation: the ability of a substance to be taken up and stored in an organism. Typically, the concentrations of the substance in the organism exceed the concentrations in the environment since the organism will store the substance and not excrete it. A bioaccumulation factor is associated with each chemical.

Volatility: the ability of a compound to partition into a gaseous state. The volatility of a compound is dependent on its water solubility and vapor pressure. The extent to which a chemical can partition into air is described by one of two constants: Henry's Law or Rauolt's Law. Other factors that are important to volatility are atmospheric temperature and waste mixing.

[1]Kolluru, Rao (1996)

result in a harmful health effect, whereas the same chemical may cause no reaction if ingested, or vice-versa. This phenomenon is due to the differences in mechanisms once a chemical enters the body. A chemical that is inhaled reaches the lungs and enters the blood system. A chemical that is ingested may pass through the liver before entering the blood system, where it may be metabolized into a different chemical that may result in a health effect or into another chemical that is soluble and can be excreted.

Some contaminants can also be absorbed by the skin. The skin is not very permeable and usually provides a sufficient barrier against most chemicals. However, some chemicals can pass through the skin in sufficient quantities to induce severe health effects. An example is carbon tetrachloride, which is readily absorbed through the skin and at certain doses can cause severe liver damage. The dermal route is typically considered in worker scenarios in which the worker is actually performing activities that involve skin contact with the chemical of concern. The tools provided in this guidance document do not address the dermal route of exposure.

b. Exposure Quantification/Estimation

Once appropriate fate and transport modeling has been performed for each pathway, providing concentrations of a chemical at an exposure point, the chemical intake by a receptor must be quantified. Quantifying the frequency, magnitude, and duration of exposures that result from the transport of a chemical to an exposure point is critical to the overall assessment. For this step, the risk assessor calculates the chemical-specific exposures for each exposure pathway identified. Exposure estimates are expressed in terms of the mass of a substance in contact with the body per unit body weight per unit time (e.g., milligrams of a chemical per kilogram body weight per day, also expressed as mg/kg-day).

The exposure quantification process requires two main areas of information gathering: the receptor activity patterns and the biological characteristics of receptors (body weight, inhalation rate). Activity patterns and biological characteristics dictate the amount of a constituent that a receptor may intake and the dose that is received per kilogram of body weight. Chemical intake values are calculated using equations that include variables for exposure concentration, contact rate, exposure frequency, exposure duration, body weight, and exposure averaging time. The values of some of these variables depend on the site conditions and the characteristics of the potentially exposed population. For example, the rate of oral ingestion of contaminated food is different for different subgroups of receptors, which might include adults, children, area visitors, subsistence farmers, and subsistence fishers. Children typically drink greater quantities of milk each day than adults per unit body weight. A subsistence fisher would be at a greater risk than another area resident from the ingestion of contaminated fish. Additionally, a child may have a greater rate of soil ingestion than an adult due to playing outdoors or hand-to-mouth behavior patterns. The activities of individuals also determine the duration of exposure. A resident may live in the area for 20 years and be in the area for more than 350 days each year. Conversely, an area visitor or a worker will have shorter exposure times. After the intake values have been estimated, they should be organized by population as appropriate (i.e., children, adult residents) so that the results in the risk characterization can be reported for each population group. To the extent feasible, site-specific values should be used for estimating the exposures; otherwise, default values suggested by the EPA in *The Exposure Factors Handbook* (EPA, 1995) may be used.

3. Risk Characterization

In the risk-characterization process, the toxicity information (slope factors, reference doses) and the results of the exposure assessment (estimated intake or dose of potentially exposed populations) are integrated to arrive at quantitative estimates of cancer and noncancer risks. To characterize the potential noncarcinogenic effects, comparisons are made between projected intake levels of substances and toxicity values. To characterize potential carcinogenic effects, probabilities that an individual will develop cancer over a lifetime are estimated from projected intake levels and chemical-specific dose-response relationships. This procedure is the final calculation step. This step determines who is likely to be affected and what the likely affects are. Because of all the assumptions inherent in deriving a risk, a risk characterization cannot be considered complete unless the numerical expressions of risk are accompanied by explanatory text interpreting and qualifying the results. The risk characterization step for carcinogens and noncarcinogens is different and is shown in the text box below.

Another consideration during the risk-characterization phase are cumulative effects.

Calculating Risk

Cancer Risks:
Incremental risk of cancer = average daily dose (mg/kg-day) * slope factor $(mg/kg\text{-}day)^{-1}$

Non-Cancer Risks
Hazard quotient = exposure or intake (mg/kg-day) or (mg/m^3)/ RfD (mg/kg-day) or RfC (mg/m^3)

A given population may be exposed to multiple chemicals from several exposure routes and sources. For example, multiple constituents may be managed in a single waste management unit, and by considering one chemical at a time the risks associated with the waste management unit may be underestimated. The EPA (1989a) has developed guidance outlined in the *Risk Assessment Guidance for Superfund*, *Volume I* to assess the overall potential for cancer and noncancer effects posed by multiple chemicals. The risk assessor, facility manager, and other interested parties should determine the appropriateness of adding the risk contribution of each chemical for each pathway to derive a cumulative cancer risk or noncancer risk. The procedures for adding risks differ for carcinogenic and noncarcinogenic effects.

Cancer Risk Equation for Multiple Substances

$$Risk_T = \Sigma Risk_i$$

where:

$Risk_T$ = the total cancer risk, expressed as a unitless probability

$Risk_i$ = the risk estimate for the i^{th} substance

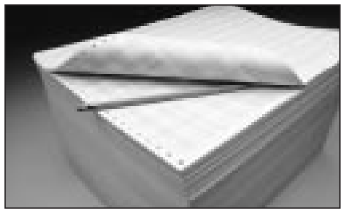
The cancer-risk equation described in the box above estimates the incremental individual lifetime cancer risk for simultaneous exposure to several carcinogens and is based on EPA (1989a) guidance. The equation combines risks by summing the risks to a receptor from each of the carcinogenic chemicals.

To assess the overall potential for noncarcinogenic effects posed by more than one chemical, a hazard index (HI) approach was developed by the EPA. The approach assumes that the magnitude of an adverse health effect is proportional to the sum of the hazard quotients of each of the chemicals investigated. Assessing cumulative effects from noncarcinogens is more difficult and contains a greater amount of uncertainty. As discussed earlier, noncarcinogenic risk covers a diverse set of health effects and different chemicals will have different effects. In keeping with EPA's *Risk Assessment Guidance*, hazard quotients should only be added for chemicals that have the same critical effect (e.g., both chemicals effect the liver or both initiate respiratory distress.) As a result, an extensive knowledge of toxicology is needed to sum the hazard quotients to produce a hazard index. Segregation of hazard indices by effect and mechanism of action can be complex, time-consuming, and will have some degree of uncertainty associated with it. This analysis is not simple and should be performed by a toxicologist.

D. Results

The results of a risk assessment provide a basis for making decisions but are only one element of input into the decision process. The risk assessment does not constitute the only basis for management action. Other factors are also important, such as technical feasibility of options, public values, and economics. Understanding and interpreting the results for the purpose of making decisions also requires a thorough knowledge of the assumptions that were applied during the risk assessment. Ample documentation should be constructed to define the scenarios that were evaluated for the risk analysis and any uncertainties there may be in the estimate. Some of the information that should be considered for inclusion in the risk assessment documentation may be: key site-related information such as contaminants evaluated, a description of the risks present (i.e., cancer, noncancer), the level of confidence in the information used in the assessment, the major factors driving the site risks, and the characteristics of the exposed population. The results of a risk assessment are essentially meaningless without the information on how they were generated.

IV. Information on Environmental Releases



Under the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986, facilities in a designated Standard Industry Code (see 40 CFR §372.22) with more than 10 employees that manufacture or process more than 25,000 pounds, or otherwise use more than 10,000 pounds, of a Toxic Release Inventory (TRI)-listed chemical are required to report their environmental releases annually to EPA and state governments. Environmental releases include the disposal of wastes in landfills, surface impoundments, land application units, and waste piles. EPA compiles these data in the TRI database. TRI data are also being made available through public libraries and reports. You may wish to include TRI data in the facility's information repository.

EPCRA is based on the belief that citizens have a right to know about potential environmental risks caused by facility operations in their communities, including those posed as a result of waste management. TRI data, therefore, provide yet another way for residents to learn about the waste management activities taking place in their neighborhood and to take a more active role in decisions that potentially affect their health and environment. More information on TRI and access to TRI data can be obtained from EPA's Web site **<www.epa.gov/opptintr/tri>.**

Building Partnerships Action Items

- ❑ Develop exhibits that provide a better understanding of facility operations.
- ❑ Identify potentially interested/affected people.
- ❑ Notify the state and public about new facilities or significant changes in facility operating plans.
- ❑ Set up a public meeting for input from the community.
- ❑ Provide interpreters for public meetings.
- ❑ Make knowledgeable and responsible people available for sharing information.
- ❑ Develop an involvement plan based on information gathered in previous steps.
- ❑ Provide access to the facility and to information about its operations.
- ❑ Maintain a publicly accessible information repository or on-site reading room.

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Part I
Getting Started

Chapter 2
Characterizing Waste

Contents

Characterizing Waste

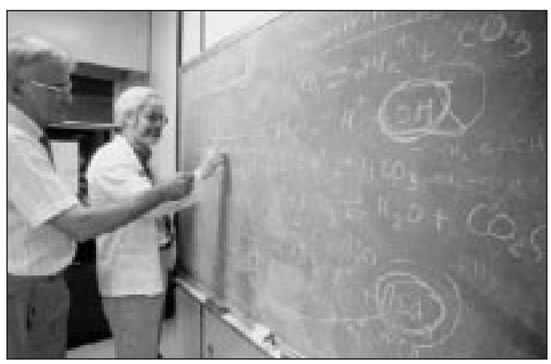
Understand the industrial processes that generate a waste. Determine the waste's physical and chemical properties. Quantify constituent leaching to facilitate ground-water risk analysis. Quantify total constituent concentrations to facilitate air emission analysis, and consideration of pollution prevention and treatment.

Understanding the physical and chemical properties of a waste and sampling and analysis procedures is the cornerstone upon which subsequent steps in this guidance are built. Knowledge of the physical and chemical properties of the waste is crucial in identifying waste reduction opportunities. It is necessary in gauging what risks a waste may pose to surface water, ground water, and air. It drives the selection of a liner or the choice of land application methods. It is needed to determine which constituents to test for if conducting ground-water monitoring. Use knowledge of waste generation processes, analytical testing, or some combination of the two to estimate waste constituent concentrations. Over time when changes are made to the industrial processes or waste management practices, it may be necessary to recharacterize a waste. No matter which approach is used in characterizing a waste, the important goal is to maximize the knowledge available to make the important decisions described in later chapters of this guidance.

This chapter will help address the following questions:

- Can process knowledge be used to characterize waste?
- What constituent concentrations should be quantified?
- What type of leachate test should be used?

I. Waste Characterization Through Process Knowledge



A waste characterization begins with an understanding of the industrial processes that generate a waste. As a starting point, obtain information about the waste itself such as the physical state of the waste, the volume, and the composition. In addition, obtain enough information about the process to enable proper characterization of the waste. Many industries have thoroughly tested and characterized their wastes over time. Check with trade associations to see if the appropriate information is available for a particular waste.

The following examples of process knowledge may assist in waste characterization by providing information on waste constituents and potential concentrations:

- Chemical engineering designs/plans for the process, showing process input chemicals, expected primary and secondary chemical reactions, and products;
- Material Safety Data Sheets (MSDSs). Note, however, that not all MSDSs contain information on all constituents found in a product;
- Manufacturer's literature;
- Previous waste analyses;
- Literature on similar processes; and
- Preliminary testing results, if available.

A materials balance exercise using process knowledge may be useful in understanding where wastes are generated within a process, and estimating the quantity of chemicals in such wastes. In a material balance, calculate all input streams, such as raw materials fed into the processes, and all output streams, such as products produced and waste generated. Material balances can assist in estimating concentrations of waste constituents where analytical test data are limited. Characterizing waste using material balances can require considerable effort and expense, but may assist in developing a more complete picture of candidate waste generation process(es). Flow diagrams are generally prepared to identify important process steps and sources where wastes are generated.

A thorough assessment of a production processes can also serve as the starting point for a facility-wide waste reduction, recycling, or pollution prevention effort. Such an assessment will provide the information base to explore many opportunities to reduce or recycle the volume or toxicity of wastes. Check the integrating pollution prevention, recycling, and treatment chapter for ideas, tools, and references on how to proceed.

II. Waste Characterization Through Leachate Testing

The intent of leaching and extraction tests is to estimate the release of waste constituents into ground water. The importance of estimating potential constituent concentrations that may leach to ground water is underscored by the fact that the ground water software model, *Industrial Waste Management Evaluation Model,* (IWEM), developed for this guidance document uses expected leachate concentrations to develop recommended liner system designs.

If the total concentration of all the constituents in a waste has been estimated using process or industry knowledge, estimates of the maximum possible concentration of these constituents in leachate can be made using the dilution ratio of the leachate test to be performed. For example, the Toxicity Characteristic Leachate Procedure (TCLP) does allow for a total constituent analysis in lieu of the TCLP extraction. If a waste is 100 percent solid, as defined by the TCLP method, then the results of the total compositional analysis may be divided by twenty to convert the total results into the maximum leachable concentration. This factor is derived from the 20:1 liquid to solid ratio employed in the TCLP. If a waste has filterable liquid, then the concentration of each phase (liquid and solid) must be determined. The following equation may be used to calculate this value:[1]

$$\frac{[A \times B] + [C \times D]}{B + [20\ (L/kg) \times D]} = E$$

Where:

A = Concentration of the analyte in liquid portion of the sample (mg/L)

B = Volume of the liquid portion of the sample (L).

C = Concentration of the analyte in solid portion of the sample (mg/kg)

D = Weight of the solid portion of the sample (kg)

E = Maximum theoretical concentration in leachate (mg/L)

Because this is only a screening method for identifying an upper-bound TCLP leachate concentration, consult with the state agency to determine whether process knowledge can be used in lieu of leachate testing.

A. Sampling and Analysis Plan

One of the more critical elements in proper waste characterization is the plan for sampling and analyzing the waste. The sampling plan is usually a written document that describes the objectives and details of the individual tasks of a sampling effort and how they will be performed. This plan should be carefully thought out, well in advance of sampling. The more detailed the sampling plan, the less opportunity for error or misunderstanding during sampling, analysis, and data treatment.

To ensure that the sampling plan is designed properly, a wide-range of personnel should be consulted. The end user of the data, an experienced member of the sampling team, a senior analytical chemist, an engineer who understands the manufacturing processes, a statistician, and a quality assurance representative all need to be involved in the development of a sampling plan. It is also wise to consult the analytical laboratory to be used. Development of sampling plans requires background information about the waste and the unit, knowledge of the waste location and situation, decisions as to the types of samples needed, and decisions as to the sampling design required. The plan should address the following considerations:

- Data quality objectives;
- Determination of a representative sample;
- Statistical methods to be employed in the analyses;
- Waste generation and handling processes;
- Constituents/parameters to be sampled;
- Physical and chemical properties of the waste;
- Accessibility of the unit;
- Sampling equipment, methods, and sample containers;
- Quality assurance and quality control (e.g., sample preservation and handling requirements);
- Chain-of-custody; and
- Health and safety of employees.

A number of these factors are discussed below. Additional information on data quality objectives and quality assurance and quality control can be found in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods—SW-846, Guidance for the Data Quality Objectives Process* (EPA600-R-96-055), *Guidance on Quality Assurance Project Plans* (EPA600-R-98-018), and *Guidance for the Data Quality Assessment: Practical Methods for Data Analysis* (EPA600-R-96-084).

[1]SW-846 Methods Team Home page at <www.epa.gov/sw-846/faqs>.

Prior to implementing a sampling plan, it is often strategic to walk through the sampling plan mentally, starting with the preparation of the equipment through the time when samples are received at the laboratory. This mental excursion should be in as much detail as can be imagined, because the small details are the ones most frequently overlooked.

1. Representative Waste Sampling

The first step in any analytical testing process is to obtain a sample that is representative of the physical and chemical composition of a waste. The term "representative sample" is commonly used to denote a sample that has the properties and composition of the population from which it was collected and in the same proportions as found in the population. This can be misleading unless dealing with a homogenous waste from which one sample can represent the whole population. Because most industrial wastes are not homogeneous, many different factors should be considered in obtaining samples that are collectively representative of a waste. Examples of factors that should be considered include:

- **Physical state of the waste.** The physical state of the waste affects most aspects of a sampling effort. The sampling device will vary according to whether the sample is liquid, gas, solid, or multiphasic. It will also vary according to whether the liquid is viscous or free-flowing, or whether the solid

More Information on Test Methods for Evaluating Solid Waste, Physical/Chemical Methods—SW-846

EPA has begun replacing requirements mandating the use of specific measurement methods or technologies with a performance-based measurement system (PBMS). The goals of PBMS is to reduce regulatory burden and foster the use of innovative and emerging technologies or methods. PBMS establishes what needs to be accomplished, but does not prescribe specifically how to do it. In a sampling situation, for example, PBMS would establish the data needs, the level of uncertainty acceptable for making decisions, and the required supporting documentation, a specific test method would not be prescribed. This approach allows the analyst the flexibility to select the most appropriate and cost effective test methods or technologies to comply with the criteria. Under PBMS, the analyst is required to demonstrate the accuracy of the measurement method using the specific matrix that is being analyzed. SW-846 serves only as a guidance document and starting point.

SW-846 provides state-of-the-art analytical test methods for a wide array of inorganic and organic constituents, as well as procedures for field and laboratory quality control, sampling, and characteristics testing. The methods are intended to promote accuracy, sensitivity, specificity, precision, and comparability of analyses and test results.

For assistance with the methods described in SW-846, call the EPA Method Information Communication Exchange (MICE) Hotline at 703 821-4690 or send an e-mail to mice@lan828.ehsg.saic.com.

SW-846 is available on line at:
<www.epa.gov/sw-846/main.htm>

A hard copy or CD-ROM version of SW-846 can be purchased by calling the National Technical Information Service (NTIS) at 703 487-4808.

is hard or soft, powdery, monolithic, or clay-like.

- **Composition of the waste.** The samples should represent the average concentration and variability of the waste in time or over space.
- **Waste generation and handling processes.** The waste generation and handling processes to account for in sampling efforts include: if the waste is generated in batches; if there is a change in the raw materials used in a manufacturing process; if waste composition can vary substantially as a function of process temperatures or pressures; and if storage time after generation may vary.
- **Transitory events.** Start-up, shut-down, slow-down, and maintenance transients can result in the generation of a waste that is not representative of the normal waste stream. If a sample was unknowingly collected at one of these intervals, incorrect conclusions could be drawn.

Consult with the state agency to identify any legal requirements or preferences before beginning sampling efforts. Refer to Chapter 9 of SW-846 for detailed guidance on planning, implementing, and assessing sampling events. To ensure that the chemical information obtained from a waste sampling efforts is accurate, it must be unbiased and sufficiently precise. Accuracy is usually achieved by incorporating some form of randomness into the sample selection process and by selecting an appropriate number of samples. Since most industrial wastes are heterogeneous in terms of their chemical properties, unbiased samples and appropriate precision can usually be achieved by simple random sampling. In this type of sampling, all units in the population (essentially all locations or points in all batches of waste from which a sample could be collected) are identified, and a suitable number of samples is randomly selected from the population.

The appropriate number of samples to employ in a waste characterization is at least the minimum number of samples required to generate a sufficiently precise estimate of the true mean concentration of a chemical contaminant in a waste. A number of mathematical formulas exist for determining the appropriate number of samples depending on the statistical precision required.

The type of sampling plan developed will vary depending on the sampling location. Solid wastes contained in a landfill or waste pile may be best sampled using a three-dimensional random sampling strategy. This involves establishing an imaginary three-dimensional grid or sampling points in the waste and then using random-number tables or random-number generators to select points for sampling. Hollow-stem augers combined with split-spoon samplers are frequently appropriate for sampling landfills.

If the distribution of waste components is known or assumed for liquid or semisolid wastes in surface impoundments, then a two-dimensional simple random sampling strategy may be appropriate. In this strategy, the top surface of the waste is divided into an imaginary grid, grid sections are selected using random-number tables or random-number generators, and each selected grid point is then sampled in a vertical manner along the entire length from top to bottom using a sampling device such as a weighted bottle, a drum thief, or Coliwasa. If sampling is restricted due to the size of the impoundment, the sampling strategy should, at a minimum, take sufficient samples to address the potential vertical anomalies in the waste in order to be considered representative. This is because contained wastes tend to display vertical, rather than horizontal, nonrandom heterogeneity due to settling of suspended solids or denser liquid phases.

To facilitate characterization efforts, consult with the state agency and a qualified professional to select a sampling plan and determine the appropriate number of samples, before beginning sampling efforts. Consider conducting a waste-stream specific characterization in sufficient detail so that the information can be used to conduct waste reduction and waste minimization activities.

Additional information concerning sampling plans, strategies, methods, equipment, and sampling quality assurance and quality control is available in chapters 9 and 10 in SW-846. Electronic versions of these chapters have been included on the CD-ROM for this guidance.

2. Representative Waste Analysis

Once a representative sample has been collected, it must be preserved to maintain the physical and chemical properties that it possessed at the time of collection. Sample types, types of sample containers, and their preparation and preservation methods are all important in maintaining the integrity of the sample. The analytical chemist must develop an analytical plan which is appropriate for the sample to be analyzed, the constituents/parameters to be analyzed for, and the end use of the information required. SW-846 contains information on analytical plans and methods. Additional references exist that are useful sources of information regarding the selection of analytical methods and quality assurance/quality control procedures for various compounds. One such web site is **<www.epa.gov/reg3hwmd/brownfld/analytic.htm>**.

B. Leachate Test Selection

Leaching tests are used to estimate potential concentration or amount of waste constituents that may leach from a waste to ground water. Typical leaching tests use a specified leaching fluid mixed with the solid portion of a waste for a specified time. Solids are then separated from the leaching solution and the solution is tested for waste constituent concentrations. The type of leaching test performed may vary depending on the chemical, biological, and physical characteristics of the waste, the environment in which the waste will be placed, as well as the recommendations or requirements of the state agency.

When selecting the most appropriate analytical procedures, consider at a minimum the physical state of the sample using process and generator knowledge, the constituents to be analyzed, detection limits, and the specified holding times of the analytical methods. It may not be cost-effective or useful to conduct a test with detection limits at or greater than the constituent concentrations in a waste. There are several general categories of phases in which samples can be categorized: solids, aqueous, sludges, multiphase samples, ground water, and oil and organic liquid. Select a procedure that is designed for the specific sample type.

> **What leachate test is appropriate?**
>
> Selecting an appropriate leachate test can be summarized in the following four steps.
>
> 1. Assess the physical state of the waste using process and generator knowledge.
> 2. Assess the environment in which the waste will be placed.
> 3. Consult with the state agency.
> 4. Select an appropriate leachate test based on the above information.

After assessing the state of the waste, assess the environment in which the waste will be placed. For example, an acidic environment may require a different test than a non-acidic environment. If the waste management unit is receiving only monofill, then the characteristics of the waste will determine most of the unit's conditions. Conversely, if wastes are being co-disposed, then the conditions created by the co-disposed wastes must be considered, including the constituents that may be leached by the subject waste.

As described in the Phase IV LDR rulemaking (62 FR 25997; May 26, 1998), EPA is undertaking a review of the TCLP test and how it is used to evaluate waste leaching. EPA anticipates that this review will examine the effects of a number of factors on leaching and on approaches to estimating the likely leaching of a waste in the environment. These factors include pH, liquid to solid ratios, matrix effects and physical form of the waste, effects of non-hazardous salts on the leachability of hazardous metal salts, and others. The effects of these factors on leaching may or may not be well reflected in the leaching tests currently available. At the conclusion of the TCLP review, EPA is likely to issue revisions to this guidance that reflect a more complete understanding of waste constituent leaching under a variety of management conditions.

Use a qualified laboratory when conducting analytical testing. The laboratory may be in-house or independent. When using independent laboratories, ensure that they are qualified and competent to perform the required tests. Some laboratories may be proficient in one test but not another. Consult with the laboratory before finalizing the test selection to ensure that it can be performed. When using analytical tests that are not frequently performed, additional quality assurance and quality control practices may be necessary to ensure that the tests were conducted correctly and that the results are accurate.

A brief summary of the TCLP and three other commonly used leachability tests is provided below. The complete procedures for all of these tests are included in SW-846 or in the *Annual Book of ASTM Standards Volume 11.04*. Appendix I provides a summary of over 20 tests designed to help determine the potential for contaminant release.[2] Consult with the state agency to identify the most appropriate test and test procedures for the waste and sample type.

1. Toxicity Characteristic Leaching Procedure

The TCLP is the test required to determine whether a waste is a toxicity characteristic hazardous waste under RCRA in 40 CFR Part 261. The TCLP estimates the leachability of certain hazardous constituents from solid waste under a defined set of laboratory conditions. It evaluates the leaching of metals, volatile and semi-volatile organic compounds, and pesticides from wastes. The TCLP was developed to simulate the leaching of constituents into ground water under conditions found in municipal solid waste (MSW) landfills. The TCLP does not simulate the release of contaminants to nonground-water pathways. The TCLP is most commonly used by EPA and state agencies to evaluate the leaching potential of wastes, and to estimate likely risks to ground water. The TCLP can be found as EPA Method 1311 in SW-846.[3] A copy of Method 1311 has been included on the CD-ROM for this guidance.

In the TCLP, liquid wastes (those containing less than 0.5 percent dry solid material) are filtered through a glass fiber filter. Waste samples containing solids and liquids are handled by separating the liquids from the solid phase, and then reducing solids to particle size. The solids are then extracted with an acetate buffer solution. A liquid-to-solid

[2] EPA has only reviewed and evaluated those test methods found in SW-846. EPA has not reviewed or evaluated the other test methods and cannot recommend any test methods other than those found in SW-846.

[3] The TCLP was developed to replace the Extraction Procedure Toxicity Test method which is designated as EPA Method 1310 in SW-846.

ratio of 20:1 by weight is used for an extraction period of 18 ± 2 hours. After extraction the solids are filtered from the liquid extract, and the liquid extract is combined with any original liquid fraction of the wastes. Analyses are then conducted on the filtrate and leachate to determine the constituent concentrations. If the extract contains any of the constituents listed in Table 1 of 40 CFR Part 261.24 at a concentration equal or greater than the respective value in the Table, unless excluded under §261.4, then the waste is considered to be a hazardous waste under the Toxicity Characteristic (TC).

Check with the state agency to determine whether the TCLP is likely to be the best test for evaluating the leaching potential of a waste, or if another test may better predict the actual leaching of a waste. The TCLP test, like other available leach tests, is designed to simulate, or approximate one set of disposal conditions and waste leaching that might occur under those conditions. It is used by EPA to classify waste as hazardous, and may be conservative in some conditions (although it has also apparently under predicted leaching in other, rather extreme, conditions). When disposal conditions are very different from the TCLP test conditions, another test may provide better short term numerical estimates of leaching.

2. Synthetic Precipitation Leaching Procedure (SPLP)

The SPLP is currently used by several state agencies to evaluate the leaching of constituents from wastes, and has been designated as EPA Method 1312 in SW-846. The SPLP was designed to estimate the leachability of both organic and inorganic analytes present in liquids, soils, and wastes. The SPLP was originally designed to assess how clean a soil was in EPA's clean closure program. The

federal hazardous waste program, however, did not adopt it for use, but the test still may estimate releases from wastes placed in a landfill and subject to acid rain. There may be, however, important differences between soil as a constituent matrix and the matrix of a generated industrial waste. A copy of Method 1312 has been included on the CD-ROM for this guidance.

The SPLP is very similar to the TCLP. Waste samples containing solids and liquids are handled by separating the liquids from the solid phase, and then reducing solids to particle size. The solids are then extracted with a dilute sulfuric acid/nitric acid solution. A liquid-to-solid ratio of 20:1 by weight is used for an extraction period of 18±2 hours. After extraction the solids are filtered from the liquid extract, and the liquid extract is combined with any original liquid fraction of the wastes. Analyses are then conducted on the filtrate and leachate to determine the constituent concentrations.

The sulfuric acid/nitric acid extraction solution used in the SPLP was selected to simulate leachate generation, in part, from acid rain. In both the SPLP and TCLP, oily, and some paint wastes, may clog the filters used to separate the extract from the solids prior to analysis, resulting in under reporting of the extractable constituent concentrations.

3. Multiple Extraction Procedure (MEP)

The MEP is designed to simulate the leaching that a waste will undergo from repetitive precipitation of acid rain on a landfill to reveal the highest concentration of each constituent that is likely to leach in a real world environment. Currently, the MEP is used in EPA's de-listing program and has been designated as EPA Method 1320 in SW-846. A copy of Method 1320 has been included on the CD-ROM for this guidance.

The MEP can be used to evaluate liquid, solid, and multiphase samples. Waste samples are extracted according to the Extraction Procedure (EP)Toxicity Test (Method 1310 of SW-846). A copy of Method 1310 has been included on the CD-ROM for this guidance. The EP Test is very similar to the TCLP Method 1311. In the EP, liquid wastes are filtered through a glass fiber filter. Waste samples containing solids and liquids are handled by separating the liquids from the solid phase, and then reducing the solids to particle size. The solids are then extracted using an acetic acid solution. A liquid-to-solid ratio of 16:1 by weight is used for an extraction period of 24 hours. After extraction the solids are filtered from the liquid extract, and the liquid extract is combined with any original liquid fraction of the wastes. The solid portions of the samples that remain after application of Method 1310 are then re-extracted using a dilute sulfuric acid/nitric acid solution. As in the SPLP, this fluid was selected to simulate leachate generation, in part, from acid rain. This time a liquid-to-solid ratio of 20:1 by weight is used for an extraction period of 24 hours. After extraction solids are once again filtered from the liquid extract, and the liquid extract is combined with the original liquid fraction of the wastes. These four steps are repeated eight additional times. If the concentration of any constituent of concern increases from the 7th or 8th extraction to the 9th extraction, the procedure is repeated until these concentrations decrease.

The MEP is intended to simulate 1,000 years of freeze and thaw cycles and prolonged exposure to a leaching medium. One advantage of the MEP over the TCLP is that the MEP gradually removes excess alkalinity in the waste. Thus, the leaching behavior of metal contaminants can be evaluated as a function of decreasing pH, which increases the solubility of most metals.

4. Shake Extraction of Solid Waste with Water or Neutral Leaching Procedure

Shake Extraction of Solid Waste with Water, or the Neutral Leaching Procedure, was developed by the American Society for Testing and Materials (ASTM) to assess the leaching potential of solid waste and has been designated as ASTM D-3987-85. This test method provides for the shaking of a water extractant and a known weight of waste of specified composition and the separation of the aqueous phase for analysis. The intent of this test method is for the final pH of the extract to reflect the interaction of the extractant with the buffering capacity of the solid waste.

The shake test is performed by mixing the solid sample with test water and agitating continuously for 18±0.25 hours. A liquid-to-solid ratio of 20:1 by weight is used. After agitation the solids are filtered from the liquid extract, and the liquid extract is analyzed.

The water extraction is meant to simulate conditions where the solid waste is the dominant factor in determining the pH of the extract. This test, however, has only been approved for certain inorganic constituents, and is not applicable to organic substances and volatile organic compounds. Copies of this procedure can be ordered by calling ASTM at 610 832-9585 or via the Internet at **<www.astm.org>.**

III. Waste Characterization of Volatile Organic Emissions

To determine whether volatile organic emissions are of concern at a unit, as described in the protecting air chapter, the concentration of all volatile organics in a waste must be known. Analytical testing may be necessary if organic concentrations cannot be estimated using process knowledge. Many tests have been developed for quantitatively extracting volatile and nonvolatile organic compounds from various sample matrices, for example extracting all of the compound present. These tests tend to be highly dependent upon the physical characteristics of the sample. Consult with the state agency before beginning testing. Refer to SW-846 Method 3500B for general guidance on selection of methods for quantitative extraction or dilution of samples for analysis by one of the semivolatile or nonvolatile determinative methods. After performing the appropriate extraction procedure, further cleanup of the sample extract may be necessary if analysis of the extract is prevented due to interferences coextracted from the sample. Method 3600 of SW-846 provides additional guidance on cleanup procedures. Following preparation of a sample, the sample is ready for further analysis. Most analytical methods are either gas chromatography (GC), high performance liquid chromatography (HPLC), gas chromatography/mass spectrometry (GC/MS), or high performance liquid chromatography/mass spectrometry (HPLC/MS). SW-846 is designed to allow the methods to be mixed-and-matched, so that sample preparation, sample cleanup, and analytical methods can be combined into a sequence, as appropriate for the particular analyte and the matrix. Consult with the state agency before finalizing the selected methodology.

Waste Characterization Action Items

- ❑ Use process knowledge to identify constituents for further analysis.
- ❑ Assess the physical state of the waste using process and generator knowledge.
- ❑ Assess the environment in which the waste will be placed.
- ❑ Consult with the state agency to determine any state specific testing requirements.
- ❑ Select an appropriate leachate test or organic constituent analysis based on the above information.

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Part I
Getting Started

Chapter 3
Integrating Pollution Prevention, Recycling, and Treatment

Contents

Integrating Pollution Prevention, Recycling, and Treatment

Consider pollution prevention, recycling, and treatment options when designing a waste management system. Pollution prevention and recycling reduce waste disposal needs and can minimize impacts across all environmental media. Treatment can reduce the volume and/or toxicity of waste. Pollution prevention, recycling, and treatment can all ease some of the burdens, risks, and liabilities of waste management.

Pollution prevention, waste reduction, waste minimization—these and similar terms describe a variety of practices that go far beyond traditional environmental compliance or single media permits for water, air, or waste management. This guidance is designed to help decide how to manage wastes protectively. Integrating pollution prevention, recycling, and treatment into policies and operations allows for opportunities to reduce the volume and toxicity of wastes, reduce waste disposal needs, and recycle and reuse materials formerly handled as wastes. In addition to the potential to save waste management costs, pollution prevention, recycling, and treatment may improve the interactions among industry, the public, and regulatory agencies; reduce liabilities and risks associated with releases from waste management units; and reduce long-term liabilities and risks associated with closure and post-closure care of waste management units.

This chapter will help address the following questions:

- What are some of the benefits of pollution prevention, recycling, and treatment?
- Where can asistance in choosing and implementing specific pollution prevention, recycling, and treatment activities be obtained?

Pollution prevention is comprehensive and emphasizes a life-cycle approach to assessing physical plant, production processes, and products to identify the best opportunities to minimize environmental impacts across all media. This approach also ensures that actions taken in one area will not increase environmental problems in another area (such as reducing wastewater discharges but increasing airborne emissions of volatile organic compounds). Pollution prevention actively involves a broad cross section of employees in creative problem solving to help achieve environmental goals and at the same time benefit a company in many other ways. For example, redesigning production processes or finding alternative materials inputs can also improve product quality, increase efficiency, and conserve raw materials.

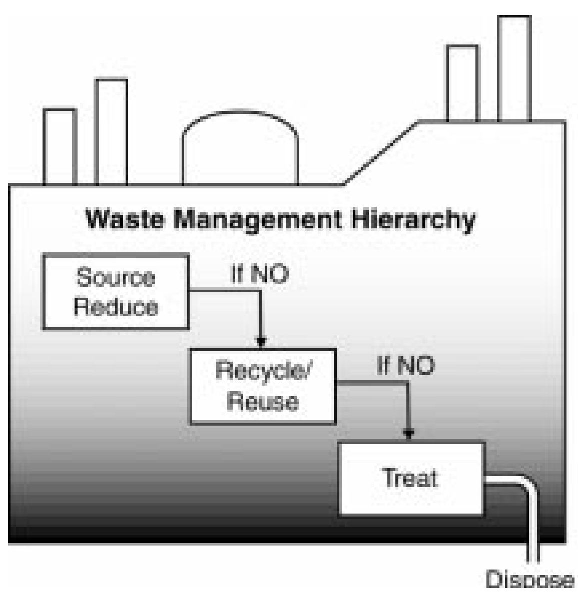
Recycling is similar to pollution prevention in the sense that both require an examination of waste streams and production processes to identify opportunities. Recycling and beneficially reusing wastes can help reduce disposal costs, while using or reusing recycled materials as substitutes for feedstocks can reduce raw materials' costs. Materials exchange programs can assist in finding uses for recycled materials, and identifying effective substitutes for raw materials. Recycling not only helps reduce the overall amount of waste sent for disposal, but also helps conserve natural resources by replacing the need for virgin materials.

Treatment can reduce the toxicity of a waste, its volume, or both. Reducing a waste's volume and toxicity prior to final disposal can result in long-term cost savings. There are a considerable number of levels and types of treatment from which to choose. Selecting the right treatment option can help simplify disposal options and limit future liability.

Throughout this guidance some key steps are highlighted that are good starting points for pollution prevention, recycling, or treatment or where pollution prevention, recycling, or treatment could help reduce waste management costs, increase options, or reduce potential liabilities by reducing risks that the wastes might pose. For example:

Waste characterization is a key component of this guidance. It is also a key component of a pollution prevention opportunity assessment. An opportunity assessment is more comprehensive, since it also covers material inputs, production processes, operating practices, and potentially other areas such as inventory control. When characterizing a waste, consider expanding the assessment to cover these aspects of the business. An opportunity assessment can help identify the most efficient, cost effective, and environmentally friendly combination of options, especially when planning new products, new or changed waste management practices, or facility expansions.

Figure 1. Waste Management Hierarchy



Land application of waste may be a preferred waste management option because land application units can manage wastes with high liquid content, achieve biodegradation, and improve soils with the organic material in the waste. Concentrations of constituents may limit the ability to take full advantage of land application. Reducing the concentrations of constituents in the waste before it is generated or treating the waste prior to land application can provide the flexibility to use land application and ensure that the practice will be protective of human health and the environment and limit future liabilities.

The Pollution Prevention Act of 1990 established a national policy to first, prevent or reduce waste at the point of generation; second, recycle or reuse waste materials; third, treat waste; and finally, dispose of remaining waste in an environmentally protective manner (see Figure 1). Some states and many local governments have adopted similar policies, often with more specific and measurable goals. Over the past 10 years, interest in all aspects of pollution prevention, recycling, and treatment has blossomed, and governments, businesses, academic and research institutions, and individual citizens have dedicated greater resources to it. Many industries are adapting pollution prevention, recycling, and treatment practices to fit their individual operations. Pollution prevention, recycling, and treatment can be successful when flexible problem-solving approaches and solutions are implemented. These steps will be successful when they fit into business and environmental goals.

I. Benefits of Pollution Prevention, Recycling, and Treatment

Pollution prevention, recycling, and treatment activities benefit industry, states, and the public by protecting the environment and reducing health risks, and also provide businesses with financial and strategic benefits.

Cost savings. Many pollution prevention activities make industrial processes and equipment more resource-efficient. This increased production efficiency saves raw material and labor costs, lowers maintenance costs due to newer equipment, and lowers oversight costs due to process simplification. When planning pollution prevention activities, consider the cost of the initial investment for audits, equipment, and labor. This cost will vary depending on the size and complexity of waste reduction activities. In addition, consider the payback time for the investment. Adjust pollution prevention activities to maximize cost savings and environmental and health benefits. Lastly, by reducing the volume and toxicity of waste, treatment activities provide savings through lower disposal costs.

Simpler design and operating conditions and reduced regulatory obligations. Reducing the risks associated with wastes may allow wastes to be managed under less stringent design and operating conditions or use of other lower-cost management practices. For example, the chapter on assessing ground-water risks may determine that a waste stream requires a composite liner. The assessment also might imply that by implementing a pollution prevention activity that lowered the concentrations of one or two problematic waste constituents in that waste stream, only a compacted clay liner may be necessary. When the risks associated with waste disposal are reduced, the long-term costs of closure and post-closure care may also be reduced.

Improved worker safety. Processes involving less toxic and less physically dangerous (such as corrosive) materials can improve worker safety by reducing work-related injuries and illnesses. In addition to strengthening morale, improved worker safety also reduces health-related costs from lost work days, health insurance, and disability payments.

Lower liability. A well-operated unit minimizes releases, accidents, and unsafe waste-handling practices. Reducing the volume and toxicity of waste decreases the impact of these events if they occur. Reducing potential liabilities, decreases the likelihood of litigation and cleanup costs.

Higher product quality. Many corporations have found that higher product quality results from some pollution prevention efforts. A significant part of waste in some operations consists of products that fail quality inspections, so minimizing waste in those cases is inextricably linked with process changes that improve quality. Often, managers do not realize how easy or technically feasible such changes are until the drive for waste reduction leads to exploration of the possibilities.

Building community relations. Honesty and openness can strengthen credibility between industries, communities and regulatory agencies. If implementing a pollution prevention program, make people aware of it. Environmental protection and economic growth can be compatible objectives. Additionally, dialogue among all parties in the development of pollution prevention plans can help identify and address concerns.

II. Implementing Pollution Prevention, Recycling, and Treatment

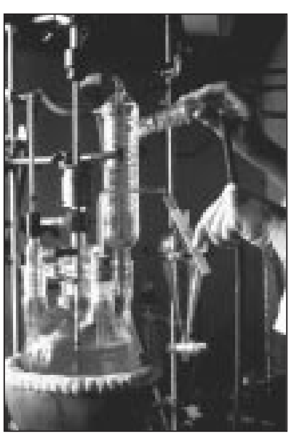
When it comes to pollution prevention, recycling, and treatment consider a combination of options that best fits a facility and its products. There are a number of steps common to any facility wide pollution prevention, recycling, and treatment effort. An essential starting point is to make a clear commitment to pollution prevention, recycling, and treatment opportunities. Seek the participation of interested partners, develop a policy statement committing the industrial operation to pollution prevention, recycling, and treatment, and organize a team to take responsibility for it. As a next step, conduct a thorough pollution prevention opportunity assessment. Such an assessment will help set priorities according to which options are the most promising. Another feature common to many pollution prevention programs is some means of measuring the program's progress and make any necessary adjustments.

The core of a program is the actual pollution prevention, recycling, and treatment practices implemented. The following sections give a brief overview of source reduction, recycling, and treatment. To find out more, contact some of the organizations listed in the appendices to this chapter.

A. Source Reduction

Source reduction is the prevention or minimization of waste at the point of generation. Some examples of source reduction activities are: input materials modification, technology modifications, in-process recycling, and various good housekeeping measures.

Input materials modification. One option is to reformulate or modify products and processes to incorporate materials less likely to produce higher-risk wastes. Some of the most common practices include eliminating metals from inks, dyes, and paints; reformulating paints, inks, and adhesives to eliminate synthetic organic solvents; and replacing chemical-based cleaning solvents with water-based or citrus-based products. Purchasing raw materials free from even trace quantities of contaminants, whenever possible, can also help reduce waste at the source.



When substituting materials in an industrial processes, it is important to examine the effect on the entire waste stream. Some changes may shift contaminants to another medium rather than actually reduce waste generation. Switching from solvent-based to water-based cleaners, for example, will reduce solvent volume and disposal cost, but is likely to dramatically increase wastewater volume. Look at the impact of wastewater generation on effluent limits and wastewater treatment sludge production.

Technological modifications. Newer process technologies often include better waste reduction features than older ones. For industrial processes that predate consideration of waste and risk reduction, altering these existing production procedures, adopting new procedures, or upgrading equipment may reduce waste volume, toxicity, and management costs. Some examples include redesigning equipment to cut losses during batch changes or during cleaning and maintenance, changing to mechanical cleaning devices to avoid solvent use, and installing more energy- and material-efficient equipment. State technical assistance centers, trade associations, and other organizations listed in Appendices I through IV can help evaluate the potential advantages and savings of such improvements.

In-process recycling (reuse). In-process recycling reuses materials, such as cutting scraps, as inputs to the same process from which they came, or uses them in other processes or for other uses in the facility. This furthers waste reduction goals by reducing the need for treatment or disposal and by conserving energy and resources. A common example of in-process recycling is reuse of wastewater.

Good housekeeping procedures. Some of the easiest and most cost-effective waste reduction techniques to implement are simple improvements in housekeeping. Accidents and spills generate avoidable disposal hazards and expenses. They are less likely to occur in clean, neatly organized facilities.

Good housekeeping techniques that reduce the likelihood of accidents and spills include training employees to manage waste and materials properly; keeping aisles wide and free of obstructions; clearly labeling containers with content, handling, storage, expiration, and health and safety information; spacing stored materials to allow easy access; surrounding storage areas with containment berms to control leaks or spills; and segregating stored materials to avoid cross-contamination, mixing of incompatible materials, and unwanted reactions. Proper employee training is crucial to implementing a successful waste reduction program, especially one featuring good housekeeping procedures. Case study data indicate that effective employee training programs can reduce waste disposal volumes by 10 to 40 percent.

Regularly scheduled maintenance and plant inspections are also useful. Maintenance helps avoid the large cleanups and disposal operations that can result from equipment failure. Routine maintenance also ensures that equipment is operating at peak efficiency, saving energy, time, and materials. Regularly scheduled or random unscheduled plant inspections help identify potential problems before they cause waste management problems. They also help identify areas where improving the efficiency of materials management and handling practices is possible. If possible, plant inspections occasionally should be performed by outside inspectors who are less familiar with day-to-day plant operations. These inspectors may notice areas for improvement that are overlooked by employees accustomed to the plant's routine practices.

Storing large volumes of raw materials increases the risk of an accidental spill and the likelihood that the materials will not be used due to changes in production schedules, new product formulations, or material degradation. Many companies are forced to dispose of materials whose expiration dates have passed or that are no longer needed. Efficient inventory control allows a facility to avoid stocking materials in excess of its ability to use them, thereby decreasing disposal volume and cost. Furthermore, some companies have successfully implemented "just-in-time" manufacturing systems to avoid the costs and risks associated with maintaining a large onsite inventory. In a "just-in-time" manufacturing system, raw materials arrive as they are needed and only minimal inventories are maintained on site.

Segregating waste streams is another good housekeeping procedure that enables a facility to avoid contaminating lower risk wastes with hazardous constituents from another source. Based on a waste characterization study, it may be more efficient and cost-effective to manage wastes separately by recycling some, and treating or disposing of others.

Waste segregation can also help reduce the risks associated with handling waste. Separating waste streams may allow some materials to be reused, resulting in additional cost savings. Emerging markets for recovered industrial waste materials are creating new economic incentives to segregate waste streams. Recovered materials are more attractive to potential buyers if it can be ensured that they are not tainted with other waste materials. If wastes from metal-finishing facilities, for example, are segregated by type, metal specific bearing sludge can be recovered more economically and the segregated solvents and waste oils can be recycled.

B. Recycling

Recycling involves collecting, processing, and reusing waste materials. The following discussion highlights a few of the ways to begin this process.

Material exchange programs. Many regions and states have established material exchange programs to facilitate transactions between waste generators and industries that can use wastes as raw materials. Material exchanges are an effective and inexpensive way to find new users and uses for a waste. Most are publicly funded, nonprofit organizations, although some charge a nominal fee to be listed with them or to access their online databases. Some actively work to promote exchanges between generators and users, while others simply publish lists of generators, materials, and buyers. Some waste exchanges also sponsor workshops and conferences to discuss waste-related regulations and to exchange information. More than 60 waste and material exchanges operate in North America. Contact information for some of these exchanges is provided in Appendix III.

Beneficial use. Beneficial use involves substituting a waste material for another material with similar properties. Utility companies, for example, often use coal combustion ash as a construction material, road base, or soil stabilizer. The ash replaces other, nonrecycled materials, such as fill or Portland cement, not only avoiding disposal costs but also generating revenue. Other examples of beneficial use include using wastewaters and sludges as soil amendments (see the chapter on designing a land application program) and using foundry sand for asphalt, concrete, and roadbed construction.

Many regulatory agencies require approval of planned beneficial use activities and may require testing of the materials to be reused. Others may allow certain wastes to be designated for beneficial use, as long as the required analyses is completed. Pennsylvania, for example, allows application of a "coproduct" designation to, and exemption from waste regulations for, "materials which are essentially equivalent to and used in place of an intentionally manufactured product or produced raw material and... [which present] no greater risk to the public or the environment." Generally, regulatory agencies want to ensure that any beneficially used materials are free from significantly increased levels of constituents that may pose a greater risk than the materials they are replacing. Consult with the state agency for criteria and regulations governing beneficial use.[1]

C. Treatment

Treating waste helps to reduce its volume and/or toxicity prior to disposal. Treatment can also make a waste amenable for reuse or recycling. The range of treatment methods from which to choose is as diverse as the

[1] Freeman, Harry. 1995. Industrial Pollution Prevention Handbook. McGraw-Hill, Inc. p. 13.

range of wastes to be treated. More advanced treatment will generally be more expensive, but, by reducing the quantity and/or risk level of the waste, costs might be reduced in the long run. Savings could come from not only lower disposal costs, but also lower closure and post-closure care costs. Conversely, more basic treatment is usually less expensive but may leave the final waste management costs higher. Choose the treatment and post-treatment waste management methods that will minimize total cost and environmental impact. Also, be sure to properly manage any treatment residuals, such as sludges, which are wastes themselves. The organizations listed in the appendices may be able to assist in identifying treatment options.

III. Where to Find Out More: Technical and Financial Assistance

There is a wealth of information available to help integrate pollution prevention, recycling, and treatment into an operation. As a starting point, lists of technical and financial resources that identify some of the main places to turn to for assistance are included in the appendices. Use the Internet as a source of background information on the various resources to help narrow the search for assistance. Eventually, a network of contacts to support all the various technical needs can be built. Waste reduction information and technologies are constantly changing. To follow new developments, maintain technical and financial contacts and use the resources even after beginning waste reduction activities.

Where can assistance be obtained?

Several types of organizations offer assistance. These include offices in regulatory agencies, university departments, nonprofit foundations, and trade associations. Additionally, the National Institute of Standards and Technology (NIST) Manufacturing Extension Partnerships (MEPs) also provide waste reduction information. Look for waste reduction staff within the media programs (air, water, solid/hazardous waste) of regulatory agencies or in the state commissioner's office, special projects division, or pollution prevention division. Some states also provide technical assistance for waste reduction activities, such as recycling, through a business advocate or small business technical assistance program.

The listings in the accompanying appendices identify some primary sources for technical assistance but are far from exhaustive. There are many additional organizations that offer waste reduction/pollution prevention assistance on regional, state, and local levels. Some of the organizations listed by state may be able to help contact these other organizations. To help locate the organizations in a state or those most relevant to an industry, the listings are divided into four appendices. Once started, the list of potential contacts can be quickly expand.

- **Appendix I: State Technical Assistance Organizations.** Regulatory and nonregulatory organizations offering various forms of technical assistance within each state.
- **Appendix II: Trade Associations.** Trade associations that can give more industry- or material-specific technical assistance resources.
- **Appendix III: North American Material Exchange Programs.** A sampling of material exchange programs across North America.
- **Appendix IV: Publications, Online Resources, and Software.** An overview of places to find general information about waste reduction options.

As contact information inevitably changes with time, check the local telephone listings or investigate online resources, such as The National Pollution Prevention Roundtable's directory, *The Pollution Prevention Yellow Pages* **<www.p2.org/nppr_yps.html>**, if trying to contact an organization that is no longer available at the number listed.

What types of technical assistance are available?

Many state and local governments have technical assistance programs that are separate from regulatory offices. In addition, nongovernmental organizations implement a wide range of activities to educate businesses about the value of waste reduction. These efforts range from providing onsite technical assistance and sharing industry-specific experiences to conducting research and developing education and outreach materials on waste reduction topics. The following examples illustrate what services are available:

- **NIST technical centers.** There are NIST-sponsored Manufacturing Technology Centers throughout the country as part of the grassroots Manufacturing Extension Partnership (MEP) program. The MEP program helps small and medium-sized companies adopt new waste reduction technologies by providing technical information, financing, training, and other services. The NIST web site **<www.nist.gov>** offers a page that can help find the nearest center.
- **Trade associations.** Trade associations provide industry-specific assistance through publications, workshops, field research, and consulting services.
- **Onsite technical assistance audits.** These audits are for small (and sometimes larger) businesses. The assessments, which take place outside of the regulatory environment and on a strictly voluntary basis, provide businesses with information on how to save money, increase efficiency, and improve community relations.
- **Information clearinghouses.** Many organizations maintain repositories of waste reduction information and serve as starting points to help businesses access this information.
- **Facility planning assistance.** A number of organizations can help businesses develop, review, or evaluate facility waste reduction plans.

State waste reduction programs frequently prepare model plans can implement to minimize waste.

- **Research and collaborative projects.** Academic institutions, state agencies and other organizations frequently participate in research and collaborative projects with industry to foster development of waste reduction technologies and management strategies. Laboratory and field research activities include studies, surveys, database development, data collection, and analysis.
- **Hotlines.** Some states operate telephone assistance services to provide technical waste reduction information to industry and the general public. Hotline staff typically answer questions, provide referrals, and distribute printed technical materials on request.
- **Computer searches and the Internet**. The Internet brings many pollution prevention resources to a user's fingertips. The wide range of resources available electronically can provide information about innovative waste-reducing technologies, efficient industrial processes, current state and federal regulations, and many other pertinent topics. Independent searches can be done on the Internet, and some states perform computer searches to provide industry with information about waste reduction. EPA and many state agencies have web sites dedicated to these topics, with case studies, technical explanations, legal information, and links to other sites for more information.
- **Workshops, seminars, and training.** State agencies, trade associations, and other organizations conduct workshops, seminars, and technical training on waste reduction. These events provide information, identify resources, and facilitate net working.
- Grants and loans. A number of states distribute funds to independent groups that conduct waste reduction activities. These groups often use such support to fund research and to run demonstration and pilot projects.

Action Items for Integrating Pollution Prevention, Recycling, and Treatment

- ❑ Make waste management decisions by considering the priorities full range of options—first, source reduction; second, reuse and recycling; third, treatment; last, disposal.
- ❑ Explore the cost savings and other benefits available through activities that integrate pollution prevention, recycling, and treatment.
- ❑ Develop a waste reduction policy.
- ❑ Conduct a pollution prevention opportunity assessment of facility processes.
- ❑ Research potential pollution prevention, recycling, and treatment activities.
- ❑ Consult with public and private agencies and organizations providing technical and financial assistance for pollution prevention, recycling, and treatment activities.
- ❑ Plan and implement activities that integrate pollution prevention, recycling, and treatment.

Resources

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Part I
Getting Started

Chapter 4
Considering the Site

Contents

Considering the Site

Become familiar with environmental, geological, and manmade features that influence siting decisions. Identify nearby areas or land uses that merit buffer zones, and place the unit an appropriate distance from them. Comply with land use and zoning restrictions. Understand existing environmental justice issues when considering a new site. Avoid siting units in problem areas, or design units to address conditions in those areas.

Many hydrologic and geologic settings can be effectively utilized for protective waste management. There are, however, some hydrologic and geologic conditions that are best avoided all together if possible. If they cannot be avoided, special design and construction precautions can minimize risks. Floodplains, earthquake zones, unstable soils, and areas at risk for subsurface movement need to be taken into account just as they would be in siting and constructing a manufacturing plant or home. Catastrophic events associated with these locations could seriously damage or destroy a unit, release contaminants into the environment, and add substantial expenses for cleanup, repair or reconstruction. If problematic site conditions cannot be avoided, engineering design and construction techniques can address some of the concerns raised by these locations.

This chapter will help address the following questions:

- What types of sites need special consideration?
- How is it determined if a unit is in an area requiring special consideration?
- What issues are associated with siting a waste management unit in such areas?
- What actions can be taken if a unit is planned in these areas?

Many state, local, and tribal governments require buffer zones between waste management units and other nearby land uses. Even if buffer zones are not required, they can still provide benefits now and in the future. Buffer zones provide time and space to contain and remedy accidental releases before they reach sensitive environments or sensitive populations. Buffer zones also help maintain good community relations by reducing disruptions associated with noise, traffic, and wind-blown dust, often the source of serious neighborhood concerns.

In considering impacts on the surrounding community, it is important to understand whether the community, especially those with large minority and low income populations, already face significant environmental impacts from existing industrial activities. Understand a community's current environmental problems and work together to develop plans that can improve and benefit the environment, the community, the state, and the company.

How should a unit site assessment begin?

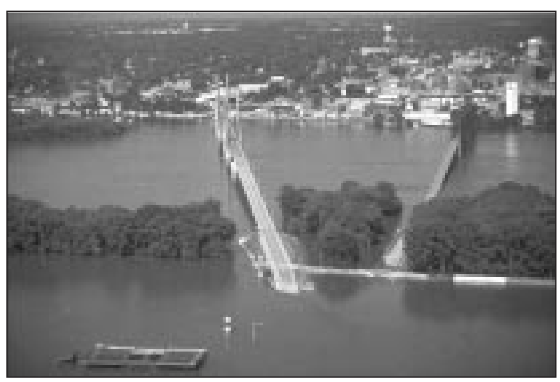
In considering whether to laterally expand a unit or site a new unit, certain factors influence prospective sites. These factors include land availability, distance from waste generation points, ease of access, local climatic conditions, economics, environmental considerations, local zoning requirements, and community impacts. As prospective sites are identified, become familiar with the siting concerns raised in this chapter, and determine how to address them at each site to minimize a unit's adverse impacts on the environment and the environment's adverse impacts on the unit. Choose the site that best balances efficient protection of human health and the environment with meeting operational goals. In addition to issues raised in this chapter, check with state and local regulatory agencies early in the siting process to identify applicable restrictions.

I. General Siting Considerations

Examining the topography of a site is the first step in siting a unit. To obtain topographic information, contact the U.S. Geological Survey (USGS), the Natural Resources Conservation Service (NRCS)[1], the state's geological survey or agency (see Appendix I), or local colleges and universities. Remote sensing data or maps from these organizations can help determine whether a prospective site is located in any of the areas of concern discussed in this section. USGS maps can be downloaded and ordered from their web page at **<mapping.usgs.gov>**. The University of Missouri-Rolla maintains a current list of State Geological Surveys on their web page at **<www.umr.edu/~library/geol/geoloff.htm>.**

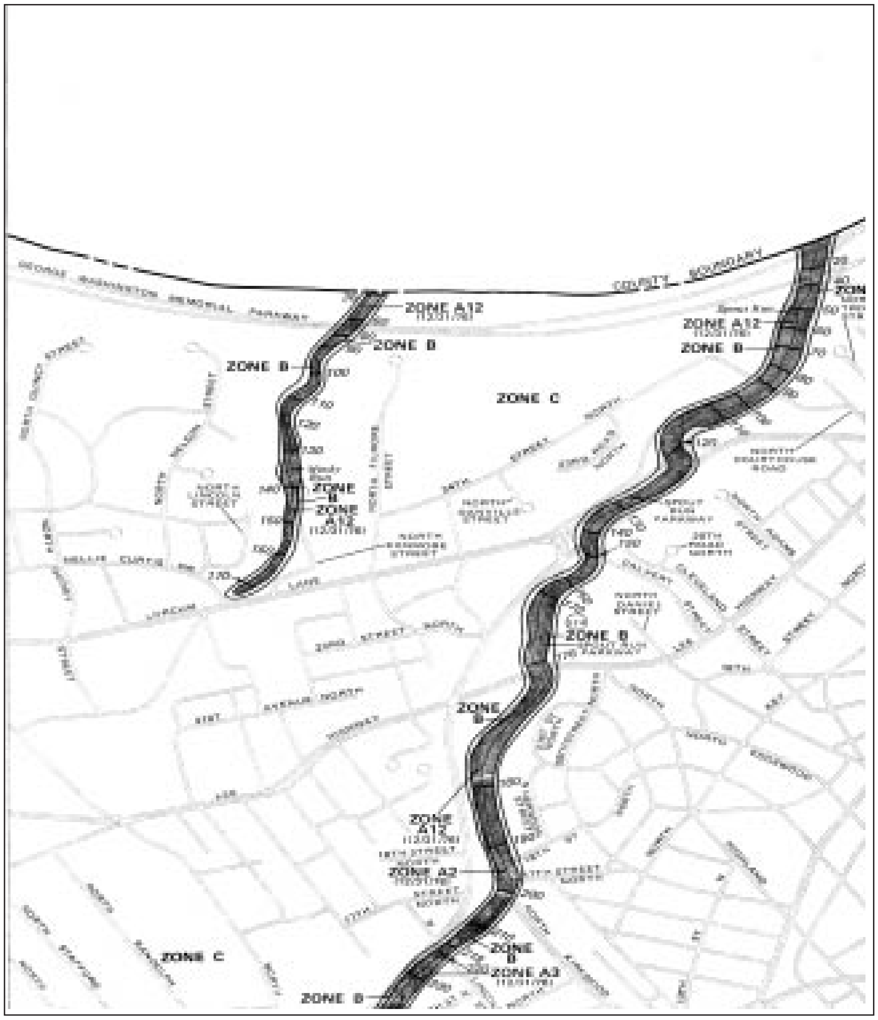
A. Floodplains

A floodplain is a relatively flat, lowland area adjoining inland and coastal waters. The 100-year floodplain—the area susceptible to inundation during a large magnitude flood with a 1 percent chance of recurring in any given year—is usually the floodplain of concern for waste management units. Determine whether a candidate site is in a 100-year floodplain. Siting a unit in a 100-year floodplain increases the likelihood of floods inundating a surface impoundment or land application unit, increases the potential to damage liner and support components of a landfill or waste pile, and presents operational concerns. This, in turn, creates environmental and human health and safety concerns, as well as legal liabilities. It also can be very costly to build a unit to withstand a 100-year flood without washout of waste or damage to the unit, or to reconstruct a unit after such a flood. Further,



Flood waters overflowed from the Mississippi River (center) into its floodplain (foreground) at Quincy, Illinois in the 1993 floods that exceeded 100-year levels in some parts of the Midwest.

[1] This agency of the U.S. Department of Agriculture was formerly known as the Soil Conservation Service (SCS).



FEMA provides flood maps like this one for most floodplains
Source: FEMA, Q3 Flood Data Users Guide **<www.fema.gov/msc>**.

locating a unit in a floodplain may exacerbate the damaging effects of a flood, both upstream and downstream, by reducing the temporary water storage capacity of the floodplain. As such, potential sites located outside the 100-year floodplain are preferable

How is it determined if a prospective site is in a 100-year floodplain?

The first step in determining whether a prospective site is located in a 100-year floodplain is to consult with the Federal Emergency Management Agency (FEMA). FEMA has prepared temporary flood hazard boundary maps for most regions. If a prospective site does not appear to be located in a floodplain, future exploration is not necessary. If uncertainty exists as to whether the prospective site may be in a floodplain, several sources of information are available to help make this determination. More detailed flood insurance rate maps (FIRMs) can be obtained from FEMA that classify areas into three classes: A, B, and C. Class A zones are the most susceptible to flooding while Class C zones are the least susceptible. FIRMs may be obtained from FEMA's web page at **<www.fema.gov/msc/hardcopy.htm>**.

Additional information can be found on flood insurance rate maps in FEMA's publication *How to Read a Flood Insurance Rate Map* (see **<www.fema.gov/NFIP/readmap.htm>**). FEMA also publishes *The National Flood Insurance Program Community Status Book*, which lists communities with flood insurance rate maps or floodway maps. Floodplain maps can also be obtained through the U.S. Army Corps of Engineers (COE); USGS; NRCS; the Bureau of Land Management; the Tennessee Valley Authority; and state, local, and tribal agencies.[2]

Note that river channels shown in floodplain maps may have changed due to hydropower or flood control projects. As a result, some floodplain boundaries may be inaccurate. If this is suspected to be the case, consult recent aerial photographs to determine how river channels have been modified.

If maps can not be located, and a potential site is suspected to be located in a floodplain, conduct a field study to delineate the floodplain and determine the floodplain's properties. A delineation can draw on meteorological records and physiographic information, such as existing and planned watershed land use, topography, soils and geographic mapping, and aerial photographic interpretation of land forms. Additionally, use the U.S. Water Resource Council's methods of determining flood potential based on stream gauge records, or estimate the peak discharge to approximate the probability of exceeding the 100-year flood.

What can be done if a prospective site is in a floodplain?

If siting a waste management unit in a floodplain, design the unit to prevent the washout of waste, avoid significant alteration of flood flow, and maintain the temporary storage capacity of the floodplain. Use engineering models to estimate a floodplain's storage capacity and floodwater flow velocity. The COE Hydrologic Engineering Center has developed several computer models for simulating flood properties.[3] The models can account for a waste management unit placed in a floodplain and can also simulate flood control structures and sediment transport. If a computer model calculates that placement of the waste management unit in the floodplain raises the base flood level by more than 1 foot, the unit may alter the storage capacity of the floodplain. If designing a new unit, site it to minimize these effects. The impact of a unit's location on the speed and flow of flood waters determines the likelihood of waste washout. To quantify this, estimate the shear stress on the unit's components caused by the impinging flood waters at the depth, velocity, and duration associated with the peak, or highest, flow period of the flood.

Several available options can protect a waste management unit from flood damage and washout.

- Design embankments using materials such as riprap—rock cover used

Knowing the behavior of waters at their peak flood level is important for determining whether waste will wash out.

[2]Copies of flood maps from FEMA are available at Map Service Center, P.O. Box 1038, Jessup, MD 20794-1038, or by phone 800 358-9616 or the Internet at <www.fema.gov/nfip/readmap.htm>.

[3]The HEC-1, HEC-2, HEC-5, and HEC-6 software packages are available free of charge through the COE World Wide Web site, <www.wrc-hec.usace.army.mil/software/software.html>.

to protect soil in dikes or channels from erosion—and/or geotextiles to minimize erosion.

- Construct dikes to serve as barrier walls to protect the disposal area. This is especially important in the case of surface impoundments.
- Consider erosion control methods, such as gabions—structures formed from crushed rock encased in wire mesh—or paving bricks and mats constructed of natural or geosynthetic materials. These materials can provide erosion protection and allow for vegetative growth.

While these methods may help protect a unit from flood damage and washout, be aware that they may further contribute to decreasing the water storage and flow capacity of the floodplain. This, in turn, may raise the level of flood waters not only in the area but in upstream and downstream locations, increasing the danger of flood damage and adding to the cost of flood control programs. Thus, serious consideration should be given to not siting a waste management unit in a 100-year floodplain.

B. Wetlands

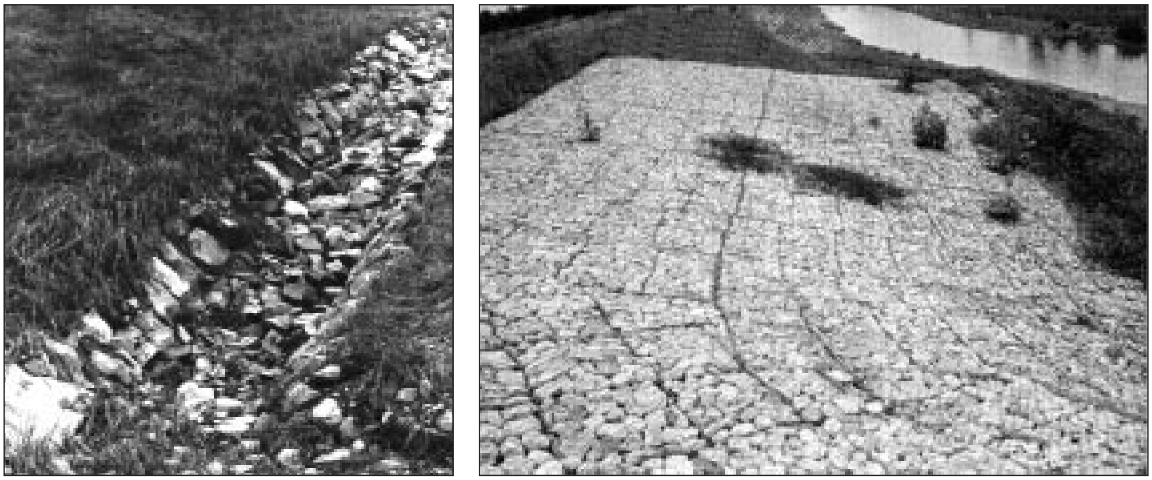
Wetlands, which include swamps, marshes, and bogs, are vital and delicate ecosystems. They are among the most productive biological communities on earth and provide habitat for many plants and animals, including approximately 45 percent of all endangered or threatened species. Wetlands protect water quality by assimilating water pollutants, removing sediments containing heavy metals, and recharging ground-water supplies. Wetlands also prevent potentially extensive and costly floods by temporarily storing flood waters and reducing their velocity. These areas also offer numerous recreational opportunities.

Potential adverse impacts associated with locating a unit in a wetland include dewatering the wetland, contaminating the wetland, and causing loss of wetland acreage. Damage also could be done to important wetland ecosystems by destroying their aesthetic qualities and diminishing wildlife breeding and feeding opportunities. Siting in a wetland also increases the potential for damage to a unit, especially the liner system and structural components, as a result of ground settlement, action of the high water table, and flooding. Alternatives to siting a waste management unit in a wetland should be given serious consideration based upon Section 404 requirements in the Clean Water Act (CWA) discussed below.

If a unit is to be sited in a wetland, the unit will be subject to additional regulations. In particular, CWA Section 404 authorizes the Secretary of the Army, acting through the Chief of Engineers (COE), to issue permits for the discharge of dredged or fill material into wetlands and other waters of the United States.[4] Activities in waters of the United States regulated under this program include fills for development, water resource projects, infrastructure improvements, and conversion of wetlands to uplands for farming and forestry. Section 404 stipulates that no discharge of dredged or fill material can be

> For regulatory purposes under the Clean Water Act, wetlands are defined as areas "that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."
>
> 40 Code of Federal Regulations (CFR) 232.2(r)

[4] 33 United States Code 1344.



Riprap reduces stream channel erosion (left) and gabions help stabilize erodible slopes (right).

Sources: U.S. Department of the Interior, Office of Surface Mining (left); The Construction Site—A Directory To The Construction Industry, **<www.constr.com>** (right).

permitted if a practicable alternative exists that is less damaging to the aquatic environment or if the nation's waters would be significantly degraded. Therefore, in compliance with the guidelines established under Section 404, all permit applicants must:

- Take steps to avoid wetland impacts where practicable;
- Minimize impacts to wetlands where they are unavoidable; and
- Compensate (offset) for any remaining, unavoidable impacts by restoring existing wetlands or creating new wetlands.

EPA and COE jointly administer a review process to issue permits for regulated activities. For projects with potentially significant impacts, an individual permit is usually required. For most discharges with only minimal adverse effects, COE may allow applicants to comply with existing general permits, which are issued on a nationwide, regional, or statewide basis for particular activity categories as a means to expedite the permitting process. In making permitting decisions, the agencies will consider numerous other federal laws that may restrict placement of waste management units in wetlands. These include the Endangered Species Act, the Migratory Bird Conservation Act, the Coastal Zone Management Act, the Wild and Scenic Rivers Act, the Marine Protection, Research and Sanctuaries Act, and the National Historic Preservation Act.

How is it known if a prospective site is in a wetland?

As a first step, determine if the prospective site meets the definition of a wetland. If the prospective site does not appear to be a wetland then no further exploration is necessary. If it is uncertain whether the prospective site is a wetland, then several sources are available to help make this determination and define the boundaries of the wetland. Although this can be a challenging process, it will help avoid future liability since filling a wetland without the appropriate federal, state, or local permit is a violation of the law. It may be possible to learn the extent of wetlands

Spruce bog (left) and Eco Pond in the Florida Everglades (right): different types of wetlands.

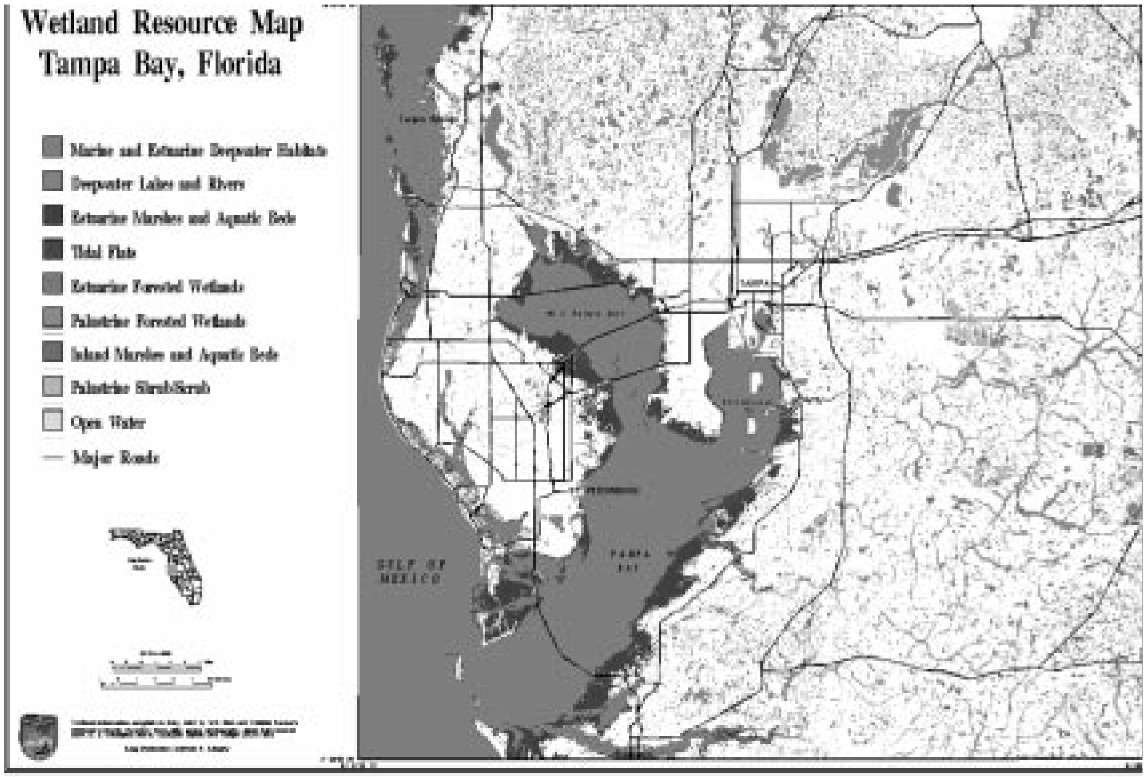
without performing a new delineation, since many wetlands have previously been mapped. The first step, therefore, should be to determine whether wetland information is available for the area. At the federal level, four agencies are principally involved with wetlands identification and delineation: COE, EPA, the U.S. Fish and Wildlife Service (FWS), and NRCS. EPA also has a Wetlands Protection Hotline (800 832-7828) and a wetlands web page at <www.epa.gov/owow/wetlands> which provides information about EPA's wetlands program; facts about wetlands; the laws, regulations, and guidance affecting wetlands; and science, education, and information resources for wetlands. The local offices of NRCS (in agricultural areas) or COE (see Appendix II for contact information) may know whether wetlands in the vicinity of the potential site have already been delineated. Additionally, FWS maintains the National Wetlands Inventory (NWI) Program[5], from which wetlands mapping for much of the United States is obtainable. This mapping, however, is based on aerial photography, which is not reliable for specific field determinations. If a site has recently been purchased, the previous property owner may know whether any delineation has been completed that may not be on file with these agencies. Even if existing delineation information for the site is found, it still may be prudent to contact a qualified wetlands consultant to verify the wetland boundaries, especially if the delineation is not a field determination or is more than a few years old.

If the existence of a wetland is uncertain, obtain a wetlands delineation. This procedure should be performed only by a qualified professional wetlands delineator[6] using standard federal delineation procedures or applicable state or local delineation standards. The delineation procedure, with which to become familiar with before hiring a delineator, involves collecting maps, aerial photographs, plant data, soil surveys, stream gauge data, land use data, and other information. Delineation for Section 404 permitting purposes should be conducted in accordance with the 1987 *U.S. Army Corps of Engineers Wetlands Delineation Manual*.[7] (HQUACE, 27 Aug. 91). The manual provides guidelines and methods to determine whether an area is a wetland for purposes of Section

[5] To contact NWI, write to National Wetlands Inventory, 9720 Executive Center Drive, Suite 101, Monroe Building, St. Petersburg, FL 33702; or call 813 570-5412; or fax 813 570-5420. For additional information online or to search for maps of an area, connect to <www.nwi.fws.gov>.

[6] In March 1995, COE proposed standards for a Wetlands Delineator Certification Program (WDCP). Until these standards are finalized, there is no federal certification program. Once the WDCP standards are implemented, use WDCP-certified wetland consultants.

[7] The 1987 manual can be obtained from NTIS (see References section below) or online at <www.wes.army.mil/el/wetlands/wlpubs.html>.



NWI wetland resource maps like this one show the locations of various different types of wetlands and are available for many areas.

Source: NWI web site, sample GIS Think Tank maps page, **<www.nwi.fws.gov/maps_tank.html>**.

404. The manual outlines a three-parameter approach that determines the presence and location of hydrophytic vegetation, wetland hydrology, and hydric soils.

What can be done if a prospective site is in a wetland?

Before building a waste management unit in a wetland area, consider whether the unit can be located elsewhere. If an alternative location can be identified, strongly consider pursuing such an option. Section 404 of the CWA requires this. As wetlands are important ecosystems that should be protected, identifying practicable alternatives to locating a unit in a wetland area is a necessary step in the siting process. Even if no viable alternative locations are identified, it may be beneficial to keep a record of investigated alternatives, noting why they were not acceptable. Such records may be useful during the interaction between industries, states, and members of the community.

If no alternatives are available, consult with state and local governments about wetland permits. Most states operate permitting programs under the CWA, and state authorities can help navigate the permitting process. To obtain a permit, the state might require an operator to assess wetland impacts and then:

- Prevent contamination from leachate and run-off;
- Minimize dewatering effects;

- Compensate the loss of wetland acreage by creating new wetlands or restoring existing ones; and
- Protect the waste management unit against settling.

C. Active Fault Areas

Faults occur when stresses in a geologic material exceed its ability to withstand them. Areas surrounding faults are subject to earthquakes and ground failures, such as landslides or soil liquefaction. Fault movement may weaken or destroy structures directly, or seismic activity associated with faulting may cause damage to structures through vibrations. Any damage to the waste management unit could result in the release of contaminants. In addition, fault movement might create avenues to ground-water supplies, increasing the risk of ground-water contamination.

Liquefaction is another common problem encountered in areas of seismic activity. The vibrating motions caused by an earthquake tend to rearrange the sand grains in soils. If the grains are saturated, the saturated granular material turns into a viscous fluid, a process referred to as liquefaction. This diminishes the bearing capacity of the soils and may lead to foundation and slope failures.

To avoid these hazards, do not build or expand a unit within 200 feet of an active fault. If it is not possible to site a unit more than 200 feet from an active fault, design the unit to withstand the potential ground movement associated with the fault area. A fault is considered active if there has been movement along the fault within the last 10,000 to 12,000 years.

How is it known if a prospective site is in a fault area?

A series of USGS maps, *Preliminary Young Fault Maps, Miscellaneous Field Investigation 916*, identifies active faults.[8] These maps may not be completely accurate due to recent shifts in fault lines. If a prospective site is well outside the 200 foot area of concern, no fault area considerations would exist. If it is unclear how close a prospective site is to an active fault, more evaluation will be necessary. A geologic reconnaissance of the site and surrounding areas may be useful in verifying that the site is free of active faults.

If a prospective site is in an area known or suspected to be prone to faulting, conduct a fault characterization to determine if the site is near a fault. A characterization includes identifying linear features that suggest the presence of faults within a 3,000-foot radius of the site. Such features might be shown or described on maps, aerial photographs,[9] logs, reports, scientific literature, or insurance claim reports, or identified by a detailed field reconnaissance of the area.

If the characterization study reveals faults within 3,000 feet of the proposed unit, conduct further investigation to determine whether any of the faults are active within 200 feet of the unit. This investigation may involve drilling and trenching the subsurface to locate fault zones and evidence of faulting. Use perpendicular trenching on any fault within 200 feet of the proposed unit to examine the seismic epicenter for indications of recent movement.

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[8] Information about ordering these maps is available by calling 800 USA-MAPS or 303 236-7477.

[9] The National Aerial Photographic Program and the National High Altitude Program, both administered by USGS, are good national sources of aerial photographs for prospective sites. To order from USGS, call 605 594-6151. For more information, visit **<www.mapping.usgs.gov/esic/aphowto.html>**. Local aerial photography firms and surveyors are also good sources.

What can be done if a prospective site is in a fault area?

If an active fault exists on the site where the unit is planned, consider placing the unit 200 feet back from the fault area. Even with such setbacks, only place a unit in a fault area if it is possible to ensure that no damage to the unit's structural integrity would result. A setback of less than 200 feet might be adequate if ground movement would not damage the unit.

If a lateral expansion or a new unit will be located in an area susceptible to seismic activity, there are two issues to consider: horizontal accelerations and movements affecting side slopes. Horizontal acceleration becomes a concern when a location analysis reveals that the site is in a zone of increased risk of horizontal acceleration in the range of 0.1 g to 0.75 g (g = acceleration of gravity). In these zones, the unit design should incorporate measures to protect the unit from potential ground shifts. To address side slope concerns, conduct a seismic stability analysis to determine the most effective materials and gradients for protecting the unit's slopes from any seismic instabilities. Further, design the unit to withstand the impact of vertical accelerations.

If an investigation reveals that a unit is in an area susceptible to liquefaction, consider ground improvement measures. These measures include grouting, dewatering, heavy tamping, and/or excavation. See Table 1 for examples of currently available techniques.

Further engineering options for fault areas include the use of flexible pipes for run-off and leachate collection and redundant containment systems. In the event of foundation soil collapse or heavy shifting, flexible run-off and leachate collection pipes—along with a bedding of gravel or permeable material—can absorb some of the shifting-related stress to which the pipes may be subjected. Consider also a secondary containment measure, such as an additional liner system. In earthquake-like conditions, a redundancy of this nature may be necessary to prevent contamination of the surrounding area if the primary liner system fails.

In this aerial view, the best-known fault in the U.S., the San Andreas, slices through the Carrizo Plain east of San Luis Obispo, California.
Source: USGS

D. Seismic Impact Zones

A seismic impact zone is an area having a 10 percent or greater probability that the maximum horizontal acceleration caused by an earthquake at the site will exceed 0.1 g in 250 years. This seismic activity may damage

Table 1
Examples of Improvement Techniques for Liquefiable Soil Foundation Conditions

Method	Principle	Most Suitable Soil Conditions/Types	Applications
Blasting	Shock waves and vibrations cause limited liquefaction, displacement, remolding, and settlement to higher density.	Saturated, clean sands; partly saturated sands and silts after flooding.	Induce liquefaction in controlled and limited stages and increase relative density to potentially nonliquefiable range.
Vibrocompaction	Densification by vibration and compaction of backfill material of sand or gravel.	Cohesionless soils with less than 20 percent fines.	Induce liquefaction in controlled and limited stages and increase relative densities to nonliquefiable condition. The dense column of backfill provides (a) vertical support, (b) drainage to relieve pore water pressure, and (c) shear resistance in horizontal and inclined directions. Used to stabilize slopes and strengthen potential failure surfaces.
Compaction piles	Densification by displacement of pile volume and by vibration during driving, increase in lateral effective earth pressure.	Loose sandy soils; partly saturated clayey soils; loess.	Useful in soils with fines. Increases relative densities to nonliquefiable range. Provides shear resistance in horizontal and inclined directions. Useful to stabilize slopes and strengthen potential failure surfaces.
Displacement and compaction grout	Highly viscous grout acts as radial hydraulic jack when pumped in under high pressure.	All soils.	Increase in soil relative density and horizontal effective stress. Reduce liquefaction potential. Stabilize the ground against movement.
Mix-in-place piles and walls	Lime, cement, or asphalt introduced through rotating auger or special in-place mixer.	Sand, silts, clays, all soft or loose inorganic soils.	Slope stabilization by providing shear resistance in horizontal and inclined directions, which strengthens potential failure surfaces or slip circles. A wall could be used to confine an area of liquefiable soil.
Heavy tamping (dynamic compaction)	Repeated application of high -intensity impacts at surface.	Cohesionless soils best, other types can also be improved.	Suitable for some soils with fines; usable above and below water. In cohesionless soils, induces liquefaction in controlled and limited stages and increases relative density to potentially nonliquefiable range.

Source: RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities. EPA600-R-95-051 leachate collection, detection, and removal systems or other unit structures through excessive bending, shearing, tension, and/or compression. If a unit's components fail, leachate may contaminate surrounding areas. For safety reasons, therefore, it is recommend that a unit not be located in a seismic impact zone. If a unit must be sited in a seismic impact zone, the unit should be designed to withstand earthquake-related hazards, such as landslides, slope failures, soil compaction, ground subsidence, and soil liquefaction.

Additionally, if a unit is built in a seismic impact zone, avoid rock and soil types that are especially vulnerable to earthquake shocks. These include very steep slopes of weak, fractured, and brittle rock or unsaturated loess, which are vulnerable to transient shocks caused by tensional faulting. Avoid loess and saturated sand as well, because seismic shocks can liquefy them, causing sudden collapse of structures. Similar effects are possible in sensitive cohesive soils when natural moisture exceeds the soil's liquid limit. (See the "Soil Properties" section in the chapter on designing and installing liners for a discussion of liquid limits.) Earthquake-induced ground vibrations can also compact loose granular soils. This could result in large uniform or differential settlements of the ground surface.

How is it known if a prospective site is in a seismic impact zone?

If a prospective site is in an area with no history of earthquakes, then seismic impact zone considerations may be unnecessary. If it is unclear whether the area has a history of seismic activity, then further evaluation will be necessary. As a first step, consult the USGS field study map series MF-2120, *Probabilistic Earthquake Acceleration and Velocity Maps for the United States and Puerto Rico*.[10] It provides state- and county-specific information about seismic impact zones. Additional information is available from the USGS National Earthquake Information Center (NEIC),[11] which maintains a database of known earthquake and fault zones.

If a site is or may be in a seismic impact zone, it also is useful to analyze the effects of seismic activity on soils in and under a unit. Computer software programs are available that can evaluate soil liquefaction potential. Liquefaction is the process by which soils change from solid to liquid state due to repeated shearing during or following an earthquake. LIQUFAC, a software program developed by the Naval Facilities Engineering Command in Washington, DC, can calculate safety factors for each soil layer in a given soil profile and the corresponding one dimensional settlements due to earthquake loading.

What can be done if a prospective site is in a seismic impact zone?

If a waste management unit cannot be sited outside a seismic impact zone, structural components of the unit—including liners, leachate collection systems, and surface-water control systems—should be designed to resist the earthquake-related stresses expected in the local soil. Consult professionals experienced in seismic analysis and design to ensure that the unit is designed appropriately. To determine the potential effects of seismic activity on a structure, the seismic design specialist should evaluate soil behavior with respect to earthquake intensity. This evaluation should account for soil strength, degree of compaction, sorting (organization of the soil

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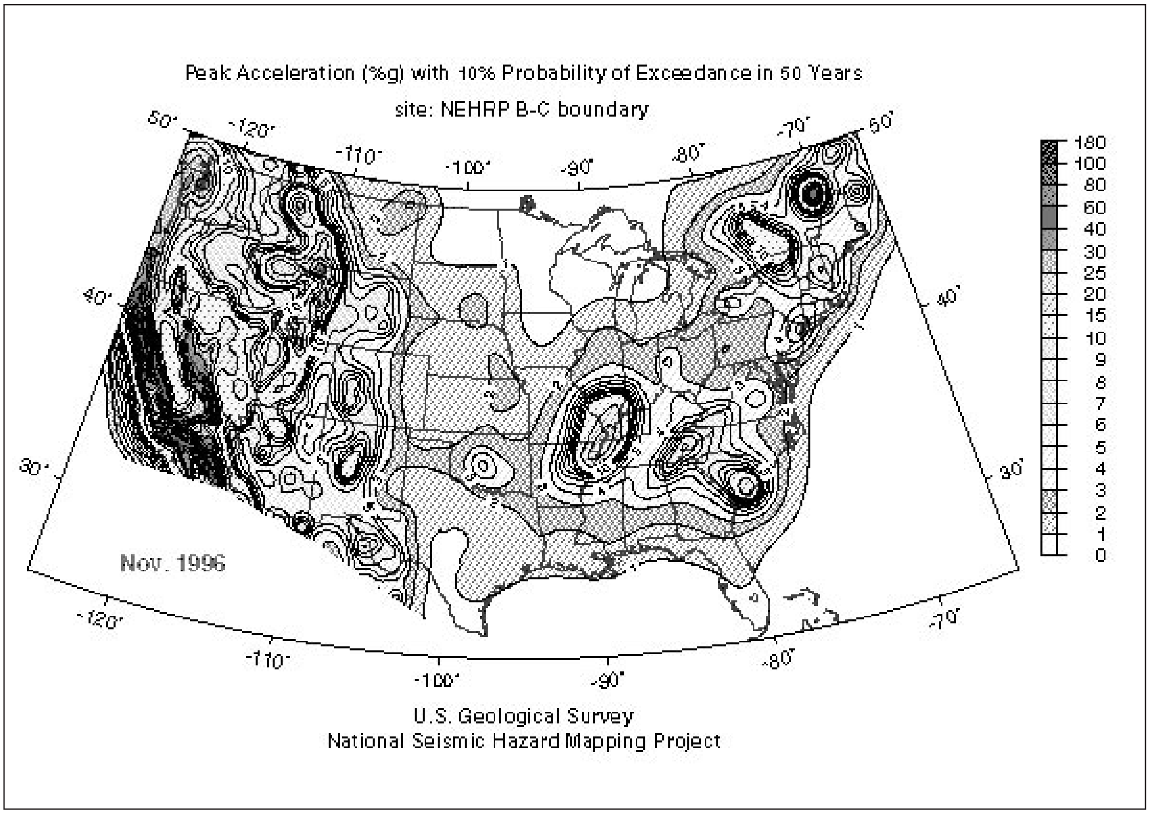
[10] For information on ordering these maps, call 800 HELP-MAP; or write: USGS Information Services, Box 25286, Denver, CO 80225; or fax 303 202-4693. On-line information is available at <www.mapping.usgs.gov/esic/to_order.html>.

[11] To contact NEIC, call 303 273-8500; or write: United States Geological Survey, National Earthquake Information Center, Box 25046, DFC, MS 967, Denver, Colorado 80225; or fax 303 273-8450; or e-mail sedas@gldfs.cr.usgs.gov. For on-line information, see <www.neic.cr.usgs.gov>.



USGS seismic impact maps like this one show the likelihood of occurance of an seismic event with a specified peak acceleration.

Source: USGS National Earthquake Information Center **<www.neic.cr.usgs.gov>**.

particles), and saturation, as well as peak acceleration of the potential earthquake.

After an evaluation of soil behavior, choose appropriate earthquake protection measures. These might include shallower slopes, dike and run-off control designs using conservative safety factors, and contingency plans or backup systems for leachate collection should the primary systems be disrupted. Unit components should be able to withstand the additional forces imposed by an earthquake within acceptable margins of safety.

Additionally, well-compacted, cohesionless embankments or reasonably flat slopes in insensitive clay (clay that maintains its compression strength when remolded) are less likely to fail under moderate seismic shocks (up to 0.15 g and 0.20 g). Embankments made of insensitive, cohesive soils founded on cohesive soils or rock may withstand even greater seismic shocks. For earthen embankments in seismic regions, consider designs with internal drainage and core materials resistant to fracturing. Prior to or during unit construction in a seismic impact zone, evaluate excavation slope stability to determine the appropriate grade of slopes to minimize potential slip.

For landfills and waste piles, use shallower waste side slopes, as steep slopes are more vulnerable to slides and collapse during earthquakes. Use fill sequencing techniques that avoid concentrating waste in one area of the unit for an extended period of time. This prevents waste side slopes from becoming too steep and unstable and alleviates differential loading of the foundation components. Placing too much waste in one area of the unit may lead to catastrophic shifting during an earthquake or heavy seismic activity. Shifting of this nature may cause failure of crucial system components or of the unit in general.

In addition, seismic impact zones have design issues in common with fault areas, especially concerning soil liquefaction and earthquake-related stresses. To address liquefaction, employ the soil improvement methods described in Table 1. Treating liquefiable soils in the vicinity of the unit will improve foundation stability and help prevent uneven settling or possible collapse of heavily saturated soils underneath or near the unit.

To protect against earthquake-related stresses, consider redundant liners and special leachate collection and removal system components, such as secondary liner systems, composite liners, and leak detection systems combined with a low permeability soil layer. These measures function as backups to the primary containment and collection systems and provide a greater margin of safety for units during possible seismic stresses. Examples of special leachate systems include high-strength, flexible materials for leachate containment systems; geomembrane liner systems underlying leachate containment systems; and perforated polyvinyl chloride or high-density polyethylene piping in a bed of gravel or other permeable material.

E. Unstable Areas

Unstable areas are locations susceptible to naturally occurring or human-induced events or forces capable of impairing the integrity of a waste management unit. Naturally occurring unstable areas include regions with poor soil foundations, regions susceptible to mass movement, or regions containing karst terrain, which may include hidden sinkholes. Unstable areas caused by human activity may include areas near cut or fill slopes, areas with excessive drawdown of ground water, and areas where significant quantities of oil or natural gas have been extracted. Siting in an unstable area may make monitoring a site or performing remediation, if necessary, impossible to do. Siting in an unstable area should be avoided. If necessary, technical and construction techniques should be considered to mitigate against potential damage.

The three primary types of failure that can occur in an unstable area are settlement, loss of bearing strength, and sinkhole collapse. Settlement can result from soil compression if a unit is, or will be, located in an unstable area over a thick, extensive clay layer. The unit's weight may force water from the compressible clay, compacting it and allowing the unit to settle. Settlement may increase as waste volume increases and may result in structural failure of the unit if it was not properly engineered. Settlement beneath a waste management unit should be assessed and compared to the elongation strength and flexibility properties of the liner and leachate collection pipe system. Even small amounts of settlement can seriously damage leachate collection piping and sumps. Engineer a unit to minimize the impacts of settlement if it is, or will be in an unstable area.

Loss of bearing strength is a failure mode that occurs in soils that tend to expand and rapidly settle or liquefy. Soil contractions and expansions may increase the risk of leachate or waste release. Another example of loss of bearing strength occurs when excavation near the unit reduces the mass of soil at the toe of the slope, thereby reducing the overall strength (resisting force) of the foundation soil.

Catastrophic collapse in the form of sinkholes can occur in karst terrain. As water,

Sinkholes, like this one that occurred just north of Orlando, Florida in 1981, are a risk of Karst terrain. Left: aerial view (note baseball diamond for scale); right: ground-level view. Photos courtesy of City of Winter Park, Florida public relations office.

especially acidic water, percolates through limestone, the soluble carbonate material dissolves, leaving cavities and caverns. Land overlying caverns can collapse suddenly, resulting in sinkholes that can be more than 100 feet deep and 300 feet wide.

How is it known if a prospective site is in an unstable area?

Before designing a waste management unit on a prospective site whose stability has not previously been assessed, a stability assessment study should be conducted by a qualified professional. The qualified professional should assess natural conditions, such as soil geology and geomorphology, as well as both surface and subsurface human-induced features or events that could cause differential ground settlement. Naturally unstable conditions can become more unpredictable and destructive if amplified by human-induced changes to the environment. If a unit is to be built at an assessed site that exhibits stability problems, tailor the design to account for any instability detected. A stability assessment may include the following steps:

Screen for expansive soils. Such soils may lose their ability to support a foundation when subjected to certain natural events, such as heavy rain, or human-made events, such as explosions. Expansive soils usually are clay-rich and, because of their molecular structure, tend to swell and shrink by taking up and releasing water. Such soils include smectite (montmorillonite group) and vermiculite clays. In addition, soils rich in white alkali (sodium sulfate), anhydrite (calcium sulfate), or pyrite (iron sulfide) also may swell as water content increases. These soils are more common in the arid western states.

Check for soil subsidence. Soils subject to rapid subsidence include loesses, unconsolidated clays, and wetland soils. Loess is a wind-deposited, moisture-deficient silt that tends to compact when wet. Unconsolidated clays can undergo considerable compaction when oil or water is removed. Similarly, wetland soils, which by their nature are water-bearing, are also subject to subsidence when water is withdrawn.

Subsidence, slippage, and other kinds of slope failure can damage structures.

Look for areas subject to mass movement or slippage. Such areas are often situated on slopes and tend to have rock or soil conditions conducive to downhill sliding. Examples of mass movements include avalanches, landslides, and rock slides. Some sites may require cutting or filling slopes during construction. Such activities may cause existing soil or rock to slip.

Search for karst terrain. Karst features are areas containing soluble bedrock, such as limestone or dolomite, that has been dissolved and eroded by water, leaving characteristic physiographic features including sinkholes, sinking streams, caves, large springs, and blind valleys. These areas are subject to extreme incidents of differential settlement, including complete ground collapse. Karst features also can hamper detection and control of leachate, which can move rapidly through hidden conduits beneath the unit. Karst maps, such as Engineering Aspects of Karst, Scale 1:7,500,000, Map No. 38077-AW-NA-07M-00, produced by the USGS[12] and state specific geological maps can be reviewed to identify karst areas.

Scan for evidence of excessive drawdown or oil and gas extraction. Removing underground water can increase the effective overburden on the foundation soils beneath the unit. Excessive drawdown of water might cause settlement or bearing capacity failure on the foundation soils. Extraction of oil or natural gas can have similar effects.

Investigate the geotechnical and geological characteristics of the site. It is important to establish soil strengths and other engineering properties. A geotechnical engineering consultant can accomplish this by performing standard penetration tests, field vane shear tests, and laboratory tests. This information will determine how large a unit can be placed safely on the site. Other soil properties to examine include water content, shear strength, plasticity, and grain size distribution.

Examine the liquefaction potential. The liquefaction potential of embankments, slopes, and foundation soils must be determined. Highly liquefiable soils are less conducive to safe operation of a waste management unit. Consult Section C above for more information about liquefiable soils.

What can be done if a prospective site is in an unstable area?

It is advisable not to locate or expand a waste management unit in an unstable area. If a unit is, or will be located in such an area, safeguard the structural integrity of the unit by incorporating appropriate measures into the design. If this is not done, the integrity of the unit may be jeopardized. For example, to safeguard the structural integrity of side slopes in an unstable area, reduce slope height, flatten slope angle, excavate a bench in the upper portion of the slope, or buttress slopes with compacted earth or rock fill. Alternatively, build retaining structures, such as retaining walls or slabs and piles. Other approaches include geotextiles and geogrids to provide additional strength, wick and toe

[12] For information on ordering this map, call 800 USA-MAPS; or write: USGS Information Services, Box 25286, Denver, CO 80225; or fax 303 202-4693. On-line information is available at <www-atlas.usgs.gov/atlasmap.html>.

drains to relieve excess pore pressures, grouting, and vacuum and wellpoint pumping to lower ground-water levels. In addition, surface drainage may be controlled to decrease infiltration, thereby reducing the potential for mud and debris slides.

Additional engineering concerns arise in the case of waste management units in areas containing karst terrain. The principal concern with karst terrains is progressive or catastrophic subsurface failure due to the presence of sinkholes, solution cavities, and subterranean caverns. The unpredictable and sometimes catastrophic nature of subsidence in these areas makes them difficult and expensive to develop. Extensive subsurface characterization studies should be completed before designing and building in these areas. Subsurface drilling, sinkhole monitoring, and geophysical testing are direct means that can be used to characterize a site. Geophysical techniques include electromagnetic conductivity, seismic refraction, ground-penetrating radar, and electrical resistivity. Use more than one technique to confirm and correlate findings and anomalies, and have a qualified geophysicist interpret the results of these explorations.

Remote sensing techniques, such as aerial photograph interpretation, can provide additional information on karst terrains. Surface mapping can help provide an understanding of structural patterns and relationships in karst terrains. An understanding of local carbonate geology and stratigraphy can help with the interpretation of both remote sensing and geophysical data.

Incorporate adequate engineering controls into any waste management unit located in karst terrain. In areas where karst development is minor, loose soils overlying the limestone may be excavated or heavily compacted to achieve the needed stability. Similarly, in areas where the karst voids are relatively small, the voids may be filled with slurry cement grout or other material.

Engineering solutions can try to compensate for the weak geologic structures by providing ground supports. For example, ground modifications, such as grouting or reinforced raft foundations, could compensate for a lack of ground strength in some karst areas. Raft constructions, which are floating foundations consisting of a concrete footing extending over a very large area, reduce and evenly distribute waste loads where soils have a low bearing capacity or where soil conditions are variable and erratic. Note, however, that raft foundations may not always prevent the extreme collapse and settlement that can occur in karst areas. In addition, due to the unpredictable and catastrophic nature of ground failure in unstable areas, the construction of raft foundations and other ground modifications tends to be complex and can be costly, depending on the size of the area.

F. Airport Vicinities

The vicinity of an airport includes not only the facility itself but also large reserved open areas beyond the ends of runways. If a unit is intended to be sited near an airport, be aware of issues that take on added importance in such areas and become familiar with Federal Aviation Administration (FAA) regulations and guidelines. The chief concern associated with waste management units near airports is the hazard posed to aircraft by birds, which often feed at units managing putrescible waste. Planes can lose propulsion when birds are sucked into jet engines, and may sustain other damage in collisions with birds. Another area of concern for landfills and waste piles near airports is the height of the accumulated waste. In such situations, exercise caution when managing waste in units that are significantly above ground level. Industrial waste management units that do not receive putrescible wastes should not have a problem with birds.

How is it known if a prospective site is in an airport vicinity?

If the prospective site is not located near any airports, additional evaluation is not necessary. If there is uncertainty whether the prospective site is located near airports, obtain local maps of the area using the Internet or from the state and identify any nearby public use airports. Topographic maps available from USGS also provide a suitable basis for determining airport locations. If necessary, FAA can provide information on the location of all public-use airports. In accordance with FAA guidance, if a new unit or an expansion of an existing unit will be within 5 miles of the end of a public-use airport runway, the affected airport and the regional FAA office should be notified to provide them an opportunity for review and comment.

What can be done if a prospective site is in an airport vicinity?

If a unit is, or will be located within 10,000 feet of an airport used by jet aircraft or within 5,000 feet of an airport used only by piston-type aircraft, design and operate the unit so it does not pose a bird hazard to aircraft and, for above-ground units, does not interfere with flight patterns. If it appears that height may be a concern, consider entrenching the unit or choosing a site outside the airport's flight patterns. The types of waste handled at most nonhazardous industrial units do not usually include attractive food sources for birds, but if a unit handles waste that may potentially attract birds, precautions should be taken to prevent birds from becoming an aircraft hazard. Discourage congregation of birds near a unit by preventing water from collecting on site; eliminating or covering wastes that might serve as a food source; constructing physical barriers, such as a canopy of fine wires or nets strung around the disposal and storage areas; using visual deterrents, including realistic models of the expected scavenger birds' natural predators; employing sound deterrents, such as cannon sounds, distress calls of scavenger birds, or the sounds of the birds' natural predators; or removing nesting and roosting areas (unless such removal is prohibited by the Endangered Species Act).

G. Wellhead Protection Areas

Wellhead protection involves sheltering the ground-water resources that supply public drinking water systems. A wellhead protection area (WHPA) is the area most susceptible to contamination surrounding a wellhead. WHPAs are designated and often regulated to prevent public drinking water sources from becoming contaminated. The technical definition, delineation, and regulation of WHPAs vary from state to state. Contact the state environmental agency to determine what wellhead protection measures are in place near prospective sites. Section II of this chapter provides examples of how some states specify minimum allowable distances between waste management units and public water supplies, as well as drinking water wells. Locating a waste management unit in a WHPA can create a potential avenue for drinking water contamination through accidental release of leachate, contaminated run-off, or waste.

How is it known if a prospective site is in a wellhead protection area?

If the prospective site is not located near a WHPA, further evaluation is not necessary. If there is uncertainty regarding the proximity of the prospective site to a WHPA, contact the state environmental agency. A list of state wellhead protection program contacts is available on EPA's web page at **<www.epa.gov/ogwdw000/wellne616a.html>**, and is included in Appendix III. Also, USGS and NRCS both can provide maps that help in delineating WHPAs. For further expertise, contact local water authorities, or universities.

What can be done if a prospective site is in a wellhead protection area?

If a new unit or lateral expansion will be located in a WHPA or suspected WHPA, consider design modifications to help prevent any ground-water contamination. For waste management units placed in these areas, work with state regulatory agencies to ensure that appropriate ground-water barriers are installed between the unit and the ground-water table. These barriers should be designed using materials of extremely low permeability, such as geomembrane liners or low permeability soil liners. The purpose of such barriers is to prevent any waste, or water that has percolated through the waste, from reaching the ground water and possibly affecting the public drinking water source.

In addition to ground-water barriers, consider using leachate collection, leak detection, and run-off control systems. Leachate contamination is possibly the greatest threat to a public ground-water supply posed by a waste management unit. Incorporating leachate collection, leak detection, and run-off control systems should further minimize leachate from escaping into the ground water.

Control systems that separate storm-water run-on from any water that has contacted waste should also be provided. Proper control measures that redirect storm water to the supply source area should help alleviate this tendency.

II. Buffer Zone Considerations

Many states require buffer zones between waste management units and other nearby land uses, such as schools. The size of a buffer zone often depends on the type of waste management unit and the land use in the surrounding areas. Consult with state regulatory agencies and local advisory boards about buffer zones before constructing a new unit or expanding an existing unit.

Buffer zones provide time and space to mitigate situations where accidental releases may cause adverse human health or environmental impacts. These zones provide four primary benefits: maintenance of quality of the surrounding ground water, prevention of contaminant migration off site, protection of drinking water supplies, and minimization of nuisance conditions perceived in surrounding areas. The size of the buffer zone will be directly related to the intended benefit.

Protecting ground water should be the primary concern for all involved parties. Ensure that materials processed and disposed of at a unit are isolated from ground-water resources. Placing a unit further from the water table, and increasing the number of physical barriers between the unit and the

Many nearby areas and land uses, such as schools, call for consideration of buffer zones.

water table, improves ground-water protection. It is therefore advised that in addition to incorporating a liner system into a waste management unit's design, a site where an adequate distance separates the bottom of a unit from the water table should be selected (see Appendix IV: State Buffer Zone Considerations: Table 5 for a summary of the most common minimum separation distances between the bottom of a waste management unit and the water table). In the event of a release, this separation distance will allow for dilution and natural attenuation to protect ground water.[13]

Additionally, in the event of an unplanned release, an adequate buffer zone will allow time for remediation activities to control contaminants before they spread off site. It also will provide additional protection for drinking water supplies. Drinking water supplies include ground water, individual and community wells, lakes, reservoirs, and municipal water treatment facilities.

Finally, buffer zones help maintain good relations with the surrounding community by protecting surrounding areas from noise, dust, and odor that may be associated with a unit. Buffer zones also help prevent access by unauthorized people. For units located near property boundaries, houses, or historic areas, evergreen trees or earthen berms can provide a buffer to reduce noise and odors. Planting trees around a unit can also improve the aesthetics of a unit, obstruct any view of unsightly waste, and help protect property values in the surrounding community.

A. Recommended Buffer Zones

Check with state and local officials to determine what buffer zones may apply to industrial waste management units.[14]

Property boundaries. Waste management units can present noise, odor, and dust problems for residents or businesses located on adjacent property, thereby diminishing property values. Additionally, proximity to property boundaries can invite increased trespassing, vandalism, and scavenging.

Drinking water wells, surface-water bodies, and public water supplies. Locating a unit near or within the recharge area, for sole source aquifers and major aquifers, coastal areas, surface-water bodies, or public water supplies, such as a community well or water treatment facility, also raises concerns. Releases from a waste management unit may pose serious threats to human health not only where water is used for drinking, but also where surface waters are used for recreation.

[13] Natural attenuation may be defined as chemical and biological processes that reduce contaminant concentrations.

[14] Appendix IV presents a summary of some state buffer zone recommendations.

Buffer zones can help protect endangered species and their habitats.

Contamination of surface waters also threatens plants and animals and their habitats.

Houses or buildings. To minimize adverse effects on adjacent properties, consider incorporating a buffer zone or separation distance into unit design. Consider planting trees or bushes to provide a natural buffer between a unit and adjacent properties.

B. Additional Buffer Zones

There are several other areas for which to consider establishing buffer zones, including critical habitats, park lands, public roads, and historic or archaeological sites.

Critical habitats. These are geographical areas occupied by endangered or threatened species. These areas contain physical or biological features essential to the proliferation of the species. When designing a unit near a critical habitat, it is imperative that the critical habitat be conserved. A buffer zone can help prevent the destruction or adverse modification of a critical habitat and minimize harm to endangered or threatened species.[15]

Parklands. A buffer between a unit and park boundaries helps maintain the aesthetics of the park land. Park lands provide recreational opportunities and a natural refuge for wildlife. Locating a unit too close to these areas can disrupt recreational qualities and natural wildlife patterns.

Public roads. A buffer zone will help reduce unauthorized access to a unit, reduce potential odor concerns, and improve aesthetics for travelers on the nearby road.

Historic or archaeological sites. A waste management unit located in close proximity to one of these sites may adversely impact the aesthetic quality of the site. These areas include historic settlements, battlegrounds, cemeteries, and Indian burial grounds. Check also whether a prospective site itself has historical or archaeological significance.

Historic sites call for careful consideration of buffer zones.

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[15]For the full text of the Endangered Species Act, go to the U.S. House of Representatives Internet Law Library at **<law.house.gov/16.htm>**.

In summary, check with local authorities to ensure that placement of a new waste management unit or lateral expansion of an existing unit will not conflict with any local buffer zone criteria. Also, review any relevant state regulations that may specify buffer zones for industrial waste management units. For new units or lateral expansions of existing units located near any sensitive areas as described in this section, consider measures to minimize any possible health, environmental, and nuisance impacts.

III. Local Land Use and Zoning Considerations

In addition to location and buffer zone considerations, become familiar with any local land use and zoning requirements. Local governments often classify the land within their communities into areas, districts, or zones. These zones represent different use categories, such as residential, commercial, industrial, or agricultural. Zoning protects public health and safety, property values, and development trends. Consider the compatibility of a unit with nearby existing and future land use and contact local authorities early in the siting process. Local planning, zoning, or public works officials can discuss the development of a unit, compliance with local regulations, and available options. Local authorities may impose conditions for protecting adjacent properties from potential adverse impacts of unit.

Addressing local land use and zoning issues during the siting process may prevent these issues from becoming prominent concerns later in the process. Land use and zoning restrictions often address impacts on community and recreational areas, historical areas, and other critical areas. Consider the proximity of a unit to such areas and evaluate any potential adverse effects it may have on these areas. For example, noise, dust, fumes, and odors from construction and operation of a unit could be considered a nuisance and legal actions may be brought by local authorities or nearby property owners.

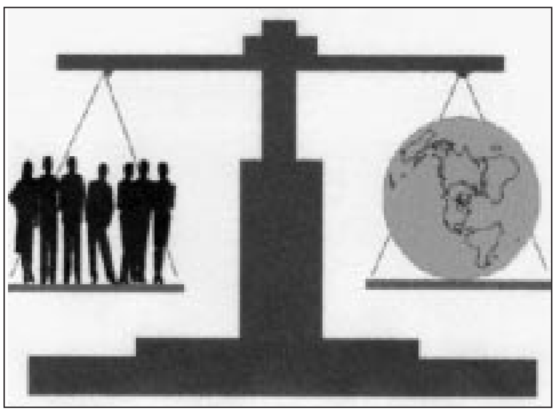
In situations where land use and zoning restrictions may cause difficulties in expanding or siting a unit, work closely with local authorities to learn about local land use and zoning restrictions and minimize potential problems. Misinterpreting or ignoring such restrictions can cause complications with intended development schedules or designs. In many cases, the use of vegetation, fences, or walls to screen activities may reduce impacts on nearby properties. In addition, it may be possible to request amendments, rezonings, special exceptions, or variances to restrictions. These administrative mechanisms allow for flexibility in use and development of land. Learning about local requirements as early as possible in the process will maximize the time available to apply for variances or rezoning permits, or to incorporate screening into the plans for a unit.

IV. Environmental Justice Considerations

In the past several years, there has been growing recognition from communities and federal and state governments that some socioeconomic and racial groups may bear a disproportionate burden of adverse environmental effects from waste management activities. President Clinton issued Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, on February 11,

1994. To be consistent with the definition of environmental justice in this executive order, identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of waste management programs, policies, and activities on minority populations and low-income populations.

One of the criticisms made by advocates of environmental justice is that local communities endure the potential health and safety risks associated with waste management units without enjoying any of the economic benefits. During unit siting or expansions, address environmental justice concerns in a manner that is most appropriate for the operations, the community, and the state. Look for opportunities to minimize environmental impacts, improve the surrounding environment, and pursue opportunities to make the waste management facility an asset to the community. When planning these opportunities, it is beneficial to maintain a relationship with all involved parties based on honesty and integrity, utilize cross-cultural formats and exchanges, and recognize industry, state, and local knowledge of the issues. It is also important to take advantage of all potential opportunities for developing partnerships.



Examples of activities that incorporate environmental justice issues include tailoring activities to specific needs; providing interpreters, if appropriate; providing multilingual materials; and promoting the formation of a community/state advisory panel.

Tailor the public involvement activities to the specific needs. Good public involvement programs are site-specific—they take into account the needs of the facility, neighborhood, and state. There is no such thing as a "one-size-fits-all" public involvement program. Listening to each other carefully will identify the specific environmental justice concerns and determine the involvement activities most appropriate to address those needs.

Provide interpreters for public meetings. Interpreters can be used to ensure the information is exchanged. Provide interpreters, as needed, for the hearing impaired and for any languages, other than English, spoken by a significant percentage of the audience.

Provide multilingual fact sheets and other information. Public notices and fact sheets should be distributed in as many languages as necessary to ensure that all interested parties receive necessary information. Fact sheets should be available for the visually impaired in the community on tape, in large print, or braille.

Promote the formation of a community/state advisory panel to serve as the voice of the community. The Louisiana Department of Environmental Quality, for example, encourages the creation of environmental justice panels comprised of community members, industry, and state representatives. The panels meet monthly to discuss environmental justice issues and find solutions to any concerns identified by the group.

Considering the Site Action Items

General Location Considerations

❑ Check to see if the proposed unit site is
- — In a 100-year floodplain;
- — Near a wetland;
- — Within 200 feet of an active fault;
- — In a seismic impact zone;
- — In an unstable area;
- — Close to an airport; or
- — Within a wellhead protection area.

❑ If the proposed unit site is in any of these areas,
- — Attempt to site the unit elsewhere first; or
- — Design the unit to account for the area's characteristics and mitigate the unit's impacts on such areas.

Buffer Zones

(Many states require buffer zones between waste management units and other nearby land uses.)

❑ Check to see if the proposed unit site is near
- — A property boundary;
- — A drinking water well;
- — A public water supply, such as a community well, reservoir, or water treatment facility;
- — A surface-water body, such as a lake, stream, river, or pond;
- — Houses or other buildings;
- — Critical habitats for endangered or threatened species;
- — Park lands;
- — A public road; or
- — Historic or archaeological sites.

❑ If the proposed unit site is near any of these areas or land uses, determine how large a buffer zone, if any, is appropriate between the unit and the area or land use.

Considering the Site Action Items (cont.)

Local Land Use and Zoning Restrictions

- ❑ Contact local planning, zoning, and/or public works agencies to discuss restrictions that may apply to the unit.
- ❑ Comply with any applicable restrictions, or obtain the necessary variances or exceptions.

Environmental Justice Issues

- ❑ Determine whether minority or low-income populations would bear a disproportionate burden of any environmental effects of the unit's waste management activities.
- ❑ Work with the community to devise strategies to minimize any potential disproportionate burdens.

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